



Digitized by the Internet Archive
in 2011 with funding from
University of Toronto

Technol.
Engin'g Dept

517

Vol. XIV

January to December, 1909

JOURNAL
OF THE
WESTERN SOCIETY
OF
ENGINEERS

PAPERS, DISCUSSIONS, ABSTRACTS, PROCEEDINGS

104827
14/9/10

CHICAGO

PUBLISHED BI-MONTHLY BY THE SOCIETY
1735 Monadnock Block

SUBSCRIPTION PRICE \$3.00 PER VOLUME
OF SIX NUMBERS

CONTENTS BY NUMBERS

Vol. XIV.—JANUARY—DECEMBER, 1909

NO. 1. JANUARY AND FEBRUARY.

	PAGE
Engineering in the West in Early Days and During the War	
Gen. Grenville M. Dodge	I
The Railroad Situation of To-day. Frank Trumbull	18
Improvement of the Upper Mississippi River.	
Col. C. McD. Townsend, M.W.S.E.	26
Engineering Work of the Wisconsin Tax and R. R. Commissions.	
Wm. D. Pence, M.W.S.E.	73
Memorials—	
Charles H. Tutton	112
Charles A. Smith	113
Proceedings of the Society—	
Minutes of Meetings	114
Annual Reports	124
Book Reviews	129
Library Notes	132
Officers of the Society	136

NO. 2. MARCH AND APRIL.

Coal Briquetting. Carl Scholz.....	137
Electrification of Railway Terminals. H. H. Evans.....	155
Manganese Steel. W. S. Potter.....	212
Relation of Load Factor to Power Costs. Messrs. Lloyd, Howlett, Waring, and others	241
Reminiscence Meeting, March 24, 1909.....	262
Proceedings of the Society—	
Minutes of the Meetings.....	283
Book Reviews	285
Trade Catalogues	296
Library Notes	299
Membership	302
Officers of the Society	304

NO. 3. MAY AND JUNE.

The Illinois Coal Field. A. Bement, M.W.S.E.....	305
Boiler Corrosion as an Electrochemical Action. Prof. C. F. Burgess, University of Wisconsin.....	375
Protective Coatings for Structural Material. R. S. Perry, Philadelphia....	399
Water Storage in Elevated Tanks and Stand Pipes. H. E. Horton, M.W.S.E.	418
Memorial—	
J. W. Schaub	436
The John Crerar Library	439

Proceedings of the Society—

Minutes of Meetings	444
Library Notes	446
Membership	447
Officers of the Society	448

No. 4. JULY AND AUGUST.

Derrick Cars and Bridge Erection, with Some Tests of Iron Pulley Blocks.

J. H. Prior, M.W.S.E.	449
The Engineering Experiment Station and Its Relation to Illinois Industries. L. P. Breckenridge, M.W.S.E.	487
Concrete-Steel Caissons; Their Development and Use for Breakwaters, Piers, and Revetments. Maj. W. V. Judson, U. S. A.	533
Memorial—	
George Adgate	609
Thomas T. Johnston	612
Proceedings of the Society—	
Minutes of Meetings	617
Book Reviews	620

No. 5. SEPTEMBER AND OCTOBER.

Some Observations on the Stability of Dams. J. F. Jackson, M.W.S.E.	625
Phases in the Development of the Street Railways of Chicago. B. J. Arnold, H. B. Fleming, George Weston, Members W.S.E.	641
Reconstruction of Street-Car Tracks in Chicago. George Weston, M.W.S.E.	673
Seventeenth National Irrigation Congress.	707
The Rensselaer Polytechnic Institute	710
Proceedings of the Society—	
Minutes of Meetings	711
Book Reviews	714
Library Notes	724
Membership	728

No. 6. NOVEMBER AND DECEMBER.

The Rolling of Special Sections of Iron and Steel. Willis McKee.	729
The Chicago Harbor. John M. Ewen, M.W.S.E.	745
Mine Accident Investigations of the United States Geological Survey. George S. Rice, M.W.S.E.	782
A Unique Type of Reinforced Concrete Construction. T. L. Condron, M.W.S.E.	822
Memorials—	
Baldwin, Henry F.	863
Birch-Nord, C. W.	864
Reynolds, Wm. E.	864
Proceedings of the Society—	
Minutes of Meetings	866
Book Reviews	875
Library Notes	880
Membership	883



Andrew Allen

President, W. S. E., 1909

Journal of the Western Society of Engineers.

VOL. XIV.

FEBRUARY, 1909.

NO. 1.

THE ENGINEERS' WORK IN THE WEST, AT AN EARLY DAY AND DURING THE CIVIL WAR

Gen. Grenville M. Dodge.

Read at the Annual Meeting, January 5, 1909.

I have been requested to talk to you about the civil engineers of my day. This is a subject of so much importance and so much breadth that it is almost impossible to grasp it. The work of the civil engineer in developing our country and in the Civil War has never been comprehended nor proper tribute paid to it, and I can only take it up in small details. Perhaps I can show it to you more clearly by stating what I personally saw of it, and this will be better than to try to go into the subject generally.

As a young boy, twenty years old, I left Norwich University, Vermont, a military college, as a civil and military engineer. My military training was perhaps of as much or more benefit to me generally than what I had learned of engineering, in the work I had to undertake, for it taught me how to command men; it gave me discipline, a respect for authority, obedience to order, loyalty to my country, and an interest in the work of my employer, that it would be impossible for me to have gotten in any other way. I came west and took an axe-man's place in an engineering party on the Illinois Central railroad. Mr. Blackstone was the division engineer with headquarters at La Salle, this state. I was assigned to a party that was running a line from La Salle to Dixon. As soon as I joined it I saw that its chief was a lazy fellow. He soon learned that I could run an instrument, and put me at that work, he staying in the house pretending to work up the data we obtained in the field. It was a cold winter, the thermometer often below zero and I thought I saw plainly the line I was running would not be acceptable and made up my mind that as soon as we returned to La Salle to leave the party and seek a berth somewhere else, for I was satisfied that Mr. Blackstone would discharge the entire party. I followed this inclination. When I returned to La Salle and submitted our work, I called upon Mr. Blackstone asking him for my pay, stating I was going to leave. He greeted me very cordially and seemed astonished at my request. However, he complied with it and I immediately left. A few years after this incident, when I had become better acquainted with Mr. Blackstone he used to make a good deal of fun of me by stating he

knew I had run the line, that it was a good line, and that he intended to give me the chief's place and put me at the head of the party, thus showing me that I was a little previous in my act, and that I did not know how good a line I had run.

When I came west I had in my mind the Pacific railroad, and as an indication to you of my enthusiasm in that quarter, I quote an extract that I wrote home from Peru, Ill., Sept. 12, 1851. It is as follows:

"I closed my last letter by saying that there was good news. "A telegraph dispatch was received here that the Rock Island "road 200 miles long was to be built, that Sheffield and Farnam "of Connecticut had taken the contract. This will give direct "connection by the Rock Island road with Wisconsin, Iowa, and "Oregon, for this is the true Pacific road and will soon be built "to Council Bluffs, where a road from St. Louis will be met "and thence to San Francisco, this being the shortest and most "feasible route. In an eastern direction, this road connects with "the Michigan Southern, which is nearly completed to Chicago "and will give us through railroad connections with New York "and Boston."

The Council Bluffs I mentioned was that named by Lewis and Clark, the town now known by that name not having been organized at that time.

I left the Illinois Central R. R. and went to the Rock Island road as axe-man under Mr. Peter A. Dey who was the division engineer stationed at Tiskilwa. I was with Mr. Dey about eight months and under his direction made a survey of the Peoria and Bureau Valley railroad in Illinois. Mr. Dey was promoted to chief engineer of the Mississippi and Missouri railroad and took me to Iowa as his principal assistant, placing me in charge of a party in the field, which was a very fine promotion for the limited experience I had. It is one of the greatest satisfactions of my life to have had the friendship of Mr. Dey from the time I entered his service. Mr. Dey is not only a very distinguished citizen of Iowa, but is one of the most eminent engineers of this country. He is known for his great ability, his uprightness, and the square dealing he gave everyone. He has greatly honored his state in the many public positions he has held. He has a wide reputation as an engineer and railway constructor, and in later years as railway commissioner of the state of Iowa.

In May, 1853, we crossed the Mississippi river at Davenport and surveyed the first railroad line across Iowa. The settlements in Iowa were then confined almost entirely to the country between Davenport and Iowa City. From Iowa City, west to Des Moines there were very few settlers and from Des Moines to Council Bluffs there were none. On reaching the Missouri river, my party was instructed to push west into the great Platte valley to determine where

a road running up that valley would strike the Missouri river. That country then was occupied solely by Indians and there was scarcely a man in my party who had seen an Indian. We crossed the river in a flat boat and I commenced the surveys west from where the city of Omaha now stands. After I had raised the bluffs skirting the Missouri, I left the party in charge of my assistant, Mr. J. E. House, and went on alone some twenty-five miles to the Elkhorn valley looking up the country ahead. On reaching the Elkhorn valley about noon, I lariatied my horse, took my rifle and hid it, and making a pillow of my saddle, lay down to take a rest. I had lost a good deal of sleep and was very tired. How long I slept there I do not know, but I was awakened by the noise of my pony. Jumping up I saw an Indian leading him towards the Elkhorn river as rapidly as he could. The pony was holding back, being evidently very much frightened at the Indian; I was greatly frightened myself, hardly knowing what to do, but I grabbed my rifle and rushed after the pony and the Indian yelling at the top of my voice. He let go the horse and swam across the Elkhorn out of my reach and I was very glad to see him go.

In 1865 during the Indian campaigns I made upon the plains, that Indian was an enlisted man in a battalion of Pawnees. He told his commander, Major North, that the reason he gave up the horse was that I made so much noise it frightened him so, it nearly scared him to death.

Returning to my party, I found them camped on the Papillion Creek, with the camp full of Indians and every man in the party cooking or feeding them. I saw that radical action had to be taken or the provisions I had would all be gone. My party was thoroughly armed. I got them together immediately and notified the Indians to get out. By my prompt action they saw we meant business and left us. From that time until I stopped my work on the plains I never allowed the party to have Indians come into camp except with the party's permission.

This is the kind of responsibility the young engineer in that day had to take. He was away from anyone to advise with or to lean upon. He was responsible for his party, its life and safety were in his hands, and in the development of this country the risks taken and the dangers faced have never been told.

From this time until the Civil War, we were engaged in building the railroad to Iowa City, the capital of Iowa, and in making reconnaissance west of the Missouri river for a Pacific railroad. It might seem strange to you that although the government spent millions of dollars in examining different routes for the Pacific railway, covering the country between parallels of 32 and 49 deg. North Latitude, which reports of examinations were printed in a dozen large volumes, no examination was made by the government upon the most feasible route across the continent; that was left to private enterprise. Our exploration and reconnaissance; up to 1860 had

determined on the 42nd parallel of latitude, practically the present line of the railroad crossing the continent. The detailed surveys had not been made, but the buffalo, the Indian, the fur trader, the telegraph, the pony express, the stage line, and finally the Engineer, determined that line and the road when built followed it.

In 1861 the Civil War came. I went into the service with six hundred other civil engineers who were graduates of Norwich University, all of whom became commissioned officers, many of them rising to the highest rank and to the highest command. Their work as civil engineers during the war was only second to that of their military duties as a soldier, and for this work as civil engineers they never have received any credit. They were mostly enlisted men, detailed as engineers; they mapped out the roads and the streams; they rebuilt the railroads and they destroyed them; they made many of our campaigns possible by their facilities in overcoming obstacles; they built temporary bridges; they showed great ingenuity in throwing up temporary entrenchments even during the battles; and they constructed impregnable forts; they were always brave, they never flinched their duty and there is no commander of a division or corps of the army but what appreciated their great and valuable service.

In 1862 I was assigned to the command of the Central Division of the Mississippi with orders to reconstruct the railroad reaching from Columbus, Kentucky, to Corinth, Mississippi, for the purpose of bringing supplies to the army then concentrated at Corinth. This line of road crossed many deep bayous which had been spanned by truss bridges, all of which had been destroyed by the enemy as they retreated. As I looked at the job before me and saw these deep bayous with no foundations and with no possible means of putting in proper abutments, or furnishing proper superstructure, it was a problem appalling to anyone. I had two Wisconsin regiments, one was commanded by Colonel George E. Bryant, who had been a Norwich University cadet and a civil engineer. He commanded a regiment that was raised in the logging camps of Wisconsin. As soon as I received this order, I ordered every engineer, civil or mechanical, or anyone who had had experience in such work in the command to report to me, and I was astonished to see the number of enlisted men who reported. We held a consultation as to how we should handle this problem, and decided to put the 12th Wisconsin into the woods with their axes, as that was about all the tools we had, and make crib piers for these streams. It was easy work for us to handle the culverts and it was astonishing how soon we built this railroad. The log cribs were bolted together by dowel pins made from the iron rods of the destroyed Howe truss bridges. We made stringers thirty and forty feet long and sunk our piers to a foundation that would carry our trains. Within two months we had rebuilt this road, and had put up at each important bridge a blockhouse, so a small force could hold it against almost any enemy;

in the celebrated raid of Forrest up through that country, where he destroyed most of the bridges south of Jackson, Tennessee, when he came to the block houses in our territory, he was repulsed at every point. This drew the attention of General Grant and he immediately ordered block houses built at every bridge on the railroads within his command.

The ingenuity of these young engineers in putting up these bridges, blockhouses and stockades; in overcoming every difficulty, and the interest they took in their work soon convinced me that all that was needed in our army for effective construction (or destruction) of a railroad was proper organization of the material in hand. The mechanics in the command put the locomotives and cars "*on their feet*" and run them, so that virtually the young engineers and young mechanics in that command *re-created* the road.

This drew the attention of General Grant and as long as my corps was under his direction or under that of General Sherman, whenever there was any destruction or reconstruction or bridge work of any kind to be accomplished, it fell to us, until the *Pioneer Corps*, of the 16th Army Corps had as good a reputation for their mechanical work as they had for their fighting ability.

In the fall of 1863 when General Grant was ordered to Chattanooga, my corps was lying at Corinth when it received orders to join Sherman in his march to the relief of Chattanooga. Having a much longer distance to march than any of the other commands, I was not able to reach Chattanooga in time to take part in that battle, but when I reached Pulaski on the Nashville and Decatur Railroad I received orders from General Grant to halt and rebuild that line from Nashville to Decatur; the entire line had been destroyed. There were several truss bridges crossing Duck river and also some very high trestles, some of them being 125 feet high, and there was the Tennessee river that had to be crossed. General Grant was very anxious to have this road built rapidly in order to feed his army at Chattanooga, which was in great distress, and Sherman told me the quicker I built the road the sooner I would get something to eat for my command; we were entirely away from any base of supplies, living off the country, and had been doing so during our entire march.

The work of the young engineers in building this road is a good deal better stated by General Grant than I can tell you, and I will read what he says:

"I gave an order to Sherman to halt General G. M. Dodge's
"command, of about eight thousand men, at Athens, and sub-
"sequently directed the latter to arrange his troops along the
"railroad from Decatur north towards Nashville, and to rebuild
"that road. The road from Nashville to Decatur passes over a
"broken country, cut up with innumerable streams, many of
"them of considerable width, and with valleys far below the
"road-bed. All the bridges over these had been destroyed, and
"the rails taken up and twisted by the enemy. All the cars and

“locomotives not carried off had been destroyed as effectually as they knew how to destroy them. All the bridges and culverts had been destroyed between Nashville and Decatur, and thence to Stevenson, where the Memphis and Charleston and the Nashville and Chattanooga roads unite. The rebuilding of this road would give us two roads as far as Stevenson over which to supply the army. From Bridgeport, a short distance farther east, the river supplements the road..

“General Dodge was an experienced railroad builder. He had no tools to work with except those of the pioneers—axes, picks and spades. With these he was able to intrench his men and protect them against surprises by small parties of the enemy. As he had no base of supplies until the road could be completed back to Nashville, the first matter to consider after protecting his men was the getting in of food and forage from the surrounding country. He had his men and teams bring in all the grain they could find, or all they needed, and all the cattle for beef, and such other food as could be found. Millers were detailed from the ranks to run the mills along the line of the army. When these were not near enough to the troops for protection they were taken down and moved up. In like manner, blacksmiths were detailed and set to work making the tools necessary in railroad and bridge building. Axemen were put to work getting out timber for bridges and cutting fuel for locomotive use when the road should be completed. Car-builders were set to work repairing the locomotives and cars. Thus every branch of railroad building, making tools to work with, and supplying the workmen with food, was all going on at once, and without the aid of a mechanic or laborer except what the command itself furnished.

“General Dodge had the work assigned him finished within forty days after receiving his orders. The number of bridges to rebuild was one hundred and eighty-two, many of them over deep and wide chasms; the length of road repaired was one hundred and two miles.”

In 1864, when it came to the Atlanta campaign, most of the railroad work, bridging, etc., was done by organized railroad men under General Wright. My command was called upon only two or three times in an emergency.

I remember when we had flanked the enemy out of the Kenesaw mountain line, our extreme right rested on the Chattahoochee river some miles southwest of the railroad crossing; General Sherman came to my headquarters and told me he proposed to flank Atlanta by moving his army by the left. We all supposed he was going by the right. He said to me there was a place called Roswell Shoals on the Chattahoochee where he desired to cross a portion of his army. He said the shoals were shallow and described them to me, asking me how long it would take for my command to build a bridge

over that stream. He stated his engineers had told him it was a big job. I looked the matter over and told him about a week. He seemed astonished and left me, but in a very short time I received orders from my commander, General McPherson, to move with my corps as rapidly as possible to Roswell some thirty-one miles away, and that I would receive orders from General Sherman. We moved and made a march of thirty-one miles without stopping except for resting our men, and reached there Sunday about noon.

When I arrived there I found that Roswell contained several large factories that had been supplying material to the enemy and I saw if I had the timber in these factories I could soon put up a bridge across the river. The enemy occupied the opposite side, and one of the most inspiring sights I ever saw was when I ordered the celebrated Ohio brigade to ford the river and take the opposite bank. They formed in column with regiment front, the corps bands were brought down to the river, the artillery was placed so as to cover their crossing, and as the boys stepped into the river carrying their cartridge boxes on their bayonets and with cheers, started to wade across the river, the bands played, the artillery opened fire, and the enemy poured in their volleys. Occasionally a boy or two would strike a hole and go under but soon come up and when they got across they rushed for the cover of a cut bank, so the enemies' fire would be less effective. There they re-formed, and charging, soon cleared the works. My pioneer corps now was very effective. It was about 1,500 strong and was organized into squads with a civil or mechanical engineer at the head of every squad. Everyone knew exactly what his duty was, just where and how to go to work, and all I had to do was to give the orders. I immediately gave the order to pull down the cotton factories that would furnish lumber and on Monday morning you could stand on the bank and see that bridge "walk up," so that Wednesday at noon, in three days, I notified Sherman that it was ready for crossing. He was astonished and sent a proper tribute to the young engineers for their quick work. My official despatch to him reads as follows:

"A footbridge 710 feet long was thrown across the river and
"from Monday noon, July 10, until Wednesday night, July 12,
"a good substantial, double track, trestle road bridge, 710 feet
"long and 14 feet high, was built by the pioneer corps from the
"command."

The cotton factories that I had torn down, were claimed by a Frenchman to belong to him; he had a French flag flying over his own residence but not over the factories. On Monday after we had torn down a portion of one of the factories, my Judge Advocate came to me and told me he thought I might be getting into trouble; that this Frenchman was entering a protest. I had gone too far to stop taking down the factories, but I thought it probably better to protect myself, and communicated with General Sherman, who wrote me a letter dated July 11th, as follows:

"Headquarters Military Division of the Mississippi.

"In the Field near Chattahoochee River, July 11, 1864.

"GENERAL DODGE, ROSWELL, GA.:

"I know you have a big job, but that is nothing new for you. "Tell General Newton that his corps is now up near General "Schofield's crossing, and all is quiet thereabout. He might "send down and move his camps to proximity of his corps, but "I think Roswell and Shallow Ford so important that I prefer "him to be near you until you are well fortified. If he needs "rations tell him to get his wagons up, and I think you will be "able to spare him day after tomorrow. I know the bridge at "Roswell is important, and you may destroy all Georgia to "make it good and strong.

W. T. SHERMAN, Major-General Commanding."

You notice that General Sherman is very diplomatic, he says nothing in relation to international law or the French flag but tells me I may destroy all Georgia to accomplish what I had to do. Of course, I read between the lines, and went on building the bridge.

Sherman commenced crossing his army over this bridge on Wednesday afternoon and made his celebrated flank movement on Atlanta where the great battles of the 19th, 22nd, and 28th of July were fought and Atlanta finally occupied.

Sherman was always profuse in his praise of the young engineers of the army that were continually at work gathering up information for us. I had a very efficient corps for that work under me and Sherman often wrote to me, thanking me for what I had been sending him, saying he would store it up for future use. This information concerning the streams, the villages and roads was compiled at his headquarters, printed on cloth and a copy sent to each corps or division commander and was of great service to us.

There was one young man detailed to me, who afterwards became a very noted engineer, Marshall S. Hurd who enlisted from Muscatine, Iowa, in the 2nd Iowa infantry. I soon discovered that he was a genius and of great ability as an engineer, of excellent practical judgment and very brave. We all tried to get him promoted and a commission given him so he could command officers and men, but we never could accomplish it. However, he virtually got to the head of the pioneer corps of the 16th Army Corps, and the boys all dubbed him "Major;" and he was known all through the war as Major Hurd, not only by the men of my corps but by the others. When he would take his pioneers out to build entrenchments, he never allowed them to run when the skirmish line of the enemy made an attack, which was often, but they would lay down their implements where they were, take their rifles, and fight it out themselves. He was very resourceful in an emergency. After the war he was connected with us on the Union Pacific and was at the head of some of the surveys both on the Union Pacific and Southern Pacific routes, fought battles with the Indians, and when the Canadian Pacific road

was built, he was sent for and went to that work, running some of the important lines over the mountain division. He was the most modest, retiring, unassuming man I ever met. He now lies buried in the cemetery at Denver with a monument raised to his memory and upon it a proper tribute to his great work. I mention him only as one among hundreds of enlisted men who performed such duties.

In May, 1866, I returned to the Union Pacific railway. Mr. Dey having resigned as chief engineer, I was appointed to that office. General Sherman in giving me leave of absence to go there and take up this work says in his letter: "As soon as General Pope reaches "Leavenworth or St. Louis to relieve you, I consent for you to go to "Omaha and begin what I trust will be the real beginning of that "great road."

Almost the first dispatch when I reached Omaha was one from the commander at Ft. Collins (he had been under me during my command of that country), telling me that a young man by the name of J. M. Eddy had brought in an engineering party which had had a fight with the Indians and that the chief of the party had been killed. I instructed him to have his party meet me on Lodge Pole creek, as I was just starting west over the line. I found that Eddy was a young soldier, who had enlisted in the 13th Illinois infantry, and had served under me in the war. In this fight, after the chief had been killed, he rallied the rest of his party and brought it in safety to the military post.

He stayed with me during the construction of the Union Pacific and also the Southern Pacific railroads; probably many of you know him, as at one time he was General Manager of the Southwestern System; he died in the service. I speak of him only as an example of what the engineers during 1866-67-68-69 had to face. The line was covered by engineers from the Missouri river to the California state line, and every party was thoroughly armed and had escorts, but many of our best men were killed.

I remember in 1867 when I was crossing the plains and reached the North Platte river near where Rawlins now stands, that Percy T. Brown, a very capable engineer in charge of the division from the Platte to the Green river, in reconnoitering that country, discovered that the divide of the continent, where we were crossing, was a basin of about 100 miles north and south, and 80 miles east and west. His party got into it but could find no streams leading out of it to the west. He took eight men for his escort to make an exploration through that basin. Near its south rim he encountered 300 Sioux Indians who were on the war path. He immediately took possession nearly dark, fought off those Indians. Just before dark, a fatal shot from an Indian hit Brown in the abdomen. He begged the men to of an elevation in the basin and there from twelve o'clock noon until leave him and save themselves, but the soldiers refused to do so. They turned loose their horses, and as soon as the Indians obtained them, they went away. These soldiers then made a litter of their

carbines and through the tall sage brush for thirteen miles that night carried Brown to Laclede stage station thinking to save him, but he died soon after reaching the station.

One of the great problems that confronted our early surveys was the crossing of the Black Hills, a spur of the Rocky Mountains. There was no trouble after reaching the summit of the Range, in descending the west slope into the Laramie plains, but the country on the east dropped off rapidly, and there was no stream or divide that we could find that was practicable for a 116 foot grade though the engineers had examined nearly every stream and every divide. The divides from the summit down, for a long distance were favorable, but just as we came to the division of the granitic and sedimentary formations, there would be a drop of five hundred feet in one thousand and we could not find supporting ground to hold our grade, to overcome this great fall.

In 1865 as I was returning from the Yellowstone country, after finishing the Indian campaigns, I took my command along the east base of the Black Hills following up the Chug Water and so on south, leaving my train every day and going on to the summit of the Black Hills with a view of trying to discover some approach from the east that was feasible. When we got down to the crossing of the "Lodge Pole," I knew that Indians were following us, but I left the command with a few cavalymen and guides with a view of following the country from the Cheyenne Pass south, also leaving strict orders with the command that if they saw smoke signals they were to come to us immediately. We worked south from the Cheyenne Pass and around the head of Crow Creek when I looked down into the valley and saw there was a band of Indians who had worked themselves in between our party and the trains. I knew it meant trouble for us, they were either after us or our stock. I therefore immediately dismounted, and giving our horses to a couple of men with instructions to keep on the west side of the ridge out of sight and gunshot, if possible, took the ridge between Lodge Pole, Crow Creek and Lone Tree Creek keeping upon it and holding the Indians away from us; our fire arms were so far reaching that when they came too near to us they were in danger as our best shots showed them.

We made signals for our cavalry but they did not seem to see them. It was getting along in the afternoon as we worked down this ridge, and I began to discover we were on an apparently very fine approach to the Black Hills, and one of the guides has stated that I said: "If we save our scalps I believed we had found a railroad line over the mountains." About four o'clock, when the Indians were preparing to take the ridge at our front, the cavalry saw our signals and soon came to our rescue, and when we reached the valley I was satisfied that the ridge we had followed was one which we could climb with a maximum grade within our charter limits and with comparatively light work.

As soon as I took charge of the Union Pacific I immediately wired

to Mr. James A. Evans, who had charge of that division, and who had been working on this mountain range for nearly a year, describing this ridge to him as I had thoroughly marked it by a lone tree on Lone Tree Creek and by a very steep cut Butte on Crow Creek, and a deep depression in the ridge where the granitic and sedimentary formations joined. He immediately made an examination and discovered a remarkably direct line, with only a ninety foot grade, reaching from the summit to the valley of Crow Creek near where Cheyenne now stands, and this summit I immediately named for my old commander, General Sherman. The Union Pacific railroad is now constructed over this line and it is one of the two eighty foot grades now left on the Union Pacific that they were unable to reduce during the re-construction of the road.

The success of the engineers in the surveying and constructing of this road was due mostly to their natural courage and ability. One of the instructions given a party when put into the field was, that the chief of the party must absolutely command it, and at all times to be ready to fight. Another was, the importance of never slacking their vigilance no matter where they were, and never being off their guard. All those who obeyed these orders, generally took their parties through, but those who did not, were soon relieved in the field or were killed by an attack of Indians. Then, again, these engineers were all men of ability, every one of them, as far as I know has risen to distinction either in his own profession or in some line of business. I know of only two of the chiefs of parties who are still living. One is a bachelor in Boston who occasionally goes out on to the plains and gathers together some of his old party, giving them a taste of their old experience by putting them back into camp again with a camp dinner, and ending with a great banquet at some prominent hotel. He is the engineer who first undertook to locate the line across Salt Lake where the road is now built. When I sent him out I gave him Captain Stanbury's soundings. The Mormons built him a boat, he put his party into it and while he was making the soundings of the lake, a terrific gale came up that swamped his boat and came very near drowning him and his party, and he reported to me that the lake was fourteen feet higher than when Stanbury sounded it in 1849, and it is a singular fact that it was then at its highest known level, for from 1870 until 1900 it continually fell. When the Union Pacific built the line across the lake it was eleven feet lower than when the original survey was made. The depth of the lake, the weight of the water, and the cost of building was beyond us and we were forced north of the lake and had to put in the high grades crossing Promontory Ridge.

The organization for the construction of the Union Pacific railroad was purely upon a military basis, nearly every man working upon it had been in the Civil War; the heads of most of the engineering parties and all of the construction forces were officers in the Civil War; the chief of the track laying force, General Casement, had been

a division commander in the Civil War, and at any moment I could call into the field a thousand men well officered, ready to meet any crisis or any emergency. There was no law in the country, and no court. We laid out the towns, officered them, kept peace and everything went on smoothly and in harmony. Two or three times at the end of our tracks a rough crowd would gather and dispute our authority, but they were soon disposed of.

I remember one incident when I was west near Salt Lake, of receiving a dispatch that a crowd of gamblers had taken our terminal point at Julesburg and refused to obey the local officers we had appointed over it. I wired General Casement to take back his track force, clean the place up and sustain the officers. When I returned to Julesburg I asked Casement what he had done. He replied: "I will show you." He took me up to a little rise just beyond Julesburg and showed me a small graveyard, saying, "General, they all died in their boots but brought peace."

The work of the engineers on the Union Pacific was a very masterful one. In the beginning they had no reliable maps or any knowledge of the country, and they explored it until they obtained a line across the country over which one locomotive, then as well as now, could haul as many cars over the line as two engines in any other of the transcontinental lines. They worked summer and winter, rain or shine. My yearly report upon the completion of the road describes better perhaps than I can now, what they accomplished and is as follows:

"They occupied the country extending from the Missouri river
"to the California state line, and covering a width of 200 miles,
"north and south, and on the general direction of the forty-second parallel of latitude; some fifteen thousand miles of instrumental lines have been run, and over twenty-five thousand miles of reconnoissance made.

"In 1863 and 1864 preliminary surveys were inaugurated, but in 1866 the country was systematically occupied; and day and night, summer and winter, the explorations were pushed forward through dangers and hardships that very few at this day appreciate, as every mile had to be run within range of the musket, as there was not a moment's security. In making surveys, numbers of our men, some of them the ablest and most promising, were killed; and during the construction our stock was run off by the hundred, I might say by the thousand; and as one difficulty after another arose and was overcome, both in the engineering, running and construction departments, a new era in railroad building was inaugurated.

"Each day taught us lessons by which we profited for the next, and our advances and improvements in the art of railway construction were marked by the progress of the work, 40 miles of track having been laid in 1865, 260 in 1866, 240 in 1867, including the ascent to the summit of the Rocky Mountains, at

“an elevation of 8,235 feet above the ocean; and during 1868
 “and to May 10, 1869, 555 miles, all exclusive of side and tem-
 “porary tracks, of which over 180 miles were built in addition.”

At Promontory Point, north of Salt Lake, Utah, on May 10, 1869, gathered there from the Atlantic and the Pacific the men who made possible this great work, who threw their fortunes, their credit and their reputation into it. They were the few bold spirits who backed the enterprise with their fortunes and their credit. They spent many millions to meet the clamor and demand of our whole nation for *speed*, and constructed a railroad 2,000 miles long in three years, when their own interests, their charter and the government allowed them ten years to complete the work. So far as it was possible for man to see, as a commercial problem, it had few, if any, advocates. It was simply considered a military necessity. Some day these men will stand in civil life like our leaderse in the Civil War. The engineers and the workmen stood in groups watching the preparations for the driving of the golden spike which should tie together with iron bands this continent. The locomotives from the east and from the west were run together and each engineer broke a bottle of champagne on their comrades machine, and a great glorification of the event was celebrated all over the country. On that day, General Sherman, not forgetting the engineers and pioneers of this work, sent me this dispatch:

“WASHINGTON, May 11, 1869.

“*General G. M. Dodge:*

“In common with millions, I sat yesterday and heard the mystic
 “taps of the telegraphic battery announce the nailing of the last
 “spike in the great Pacific road. Indeed, am I its friend? Yea.
 “Yet, am I to be a part of it, for as early as 1854 I was Vice-
 “President of the effort begun in San Francisco under the con-
 “tract of Robinson, Seymour & Company. As soon as General
 “Thomas makes certain preliminary inspections in his new com-
 “mand on the Pacific, I will go out and, I need not say, will have
 “different facilities from that of 1846, when the only way to
 “California was by sail around Cape Horn, taking our ships 196
 “days. All honor to you, to Durant, to Jack and Dan Casement,
 “to Reed and the thousands of brave fellows who have wrought
 “out this glorious problem, spite of changes, storms, and even
 “doubts of the incredulous, and all the obstacles you have now
 “happily surmounted.

“W. T. SHERMAN, *Gen.*”

How well all did their work I leave to the distinguished commis-
 sion of engineers appointed by Act of Congress to examine, review
 and report upon the completion of the Union Pacific railroad, which
 is as follows:

“Taken as a whole, the Union Pacific railroad has been well
 “constructed. The general route for the line is exceedingly well

“chosen, crossing the Rocky Mountain ranges at some of the
 “most favorable passes on the continent, and possessing capabili-
 “ties for easy grades and favorable ailgnments unsurpassed by
 “any other railway line on similarly elevated grounds. The
 “energy and preseverance with which the work has been urged
 “forward, and the rapidity with which it has been executed are
 “without parallel in history. In the grandeur and magnitude of
 “the undertaking, it has never been equaled, and no other line
 “compares with this in the arid and barren character of the
 “country it traverses, giving rise to unusual inconveniences and
 “difficulties, and imposing the necessity of obtaining almost every
 “requisite of material, of labor, and supplies for its construction,
 “from the extreme initial point of its commencement.

“G. K. WARREN, *Brevet Major-General, U. S. A.*,

“J. BLICKENSDECKER, JR., *Civil Engineer*,

“JAMES BARNES, *Civil Engineer*,

“*Special Commissioners, Union Pacific, R. R.*”

In the last five years the Union Pacific and the Southern Pacific have been virtually reconstructed under the able management of Mr. Harriman. The Union Pacific in bringing its grades to a maximum of forty-seven feet per mile excepting the eighty-foot grade rising the mountains from the east, at Cheyenne and the eighty foot grade rising the Washatch range west, from the town Echo, and in shortening the line some thirty miles, has spent almost, if not fully as much money as it took to construct the road, and the distinguished engineer who had charge of that work is now the chief engineer of the Rock Island system and he pays this tribute to the engineers and builders of the original line:

“It may appear to those unfamiliar with the character of the
 “country that the great saving in distance and reduction of grade
 “would stand as a criticism of the work of the pioneer engineers
 “who made the original location of the road. Such is not the
 “case. The changes made have been expensive and could be war-
 “ranted only by the volume of traffic handled at the present day.
 “Too much credit cannot be given Gen. G. M. Dodge and his
 “assistants. They studied their task thoroughly and performed
 “it well. Limited by law to a maximum gradient of 116 feet to
 “the mile, not compensated for curvature, they held it down to
 “about 90 feet per mile. Taking into consideration the existing
 “conditions thirty-five years ago; lack of maps of the country,
 “hostility of the Indians, which made United States troops nec-
 “essary for protection of surveying parties, difficult transporta-
 “tion, excessive cost of labor, uncertainty as to probable volume
 “of traffic, limited amount of money and the necessity to get the
 “road built as soon as possible, it can be said, with all our pres-
 “ent knowledge of the topography of the country, that the line
 “was located with very great skill.”

Since the public statements of Mr. Harriman and this tribute by Mr. Berry we have heard no more talk of the unnecessary miles of road that were built for the purpose of obtaining the government subsidy.

Upon completion of the Union Pacific railroad I was called upon by the Pennsylvania railroad interests, to organize the construction company and build the Texas Pacific railroad from New Orleans to San Diego, California, and in 1870 we marshalled our forces and covered the line with engineers from Marshall, Texas, to California. We were in the same condition in this work that we were on the Union Pacific; without any railroad connection, depending upon the Red river for our supplies and materials, and of course that river went dry, but, nevertheless, the engineers pushed on into the country where they had the Indians, among many other difficulties to contend with. I put Hurd's party into the most difficult Indian country. He had not been there long before I received a letter from the governor of the state telling me that Hurd had attacked and killed some of the friendly bands of Indians out at what was known as Sulphur Springs at the foot of the Staked Plains. Hurd was too far away for me to communicate with him, but I sent him the governor's letter. He was a man of few words; his work always told for itself in his maps and profiles, and he answered the governor's letter in a very short response which he sent me to approve and forward. In it he stated that the Sulphur Springs was the only water within fifty miles of him, when he reached there it was held by the Indians and they refused to let him have any water or allow him to approach the springs. They would not even sell it to him, and he said:

"Of course, I took the springs. I don't know whether I hurt

"any Indians or not, and I do not care, but I knew better than to

"go back to General Dodge and tell him that I had been forced

"to abandon my survey by two or three hundred bare-backed

"Indians without fighting them."

That was the last heard of that complaint.

On the line through Arizona we had a very noted engineer, Capt. R. W. Petriken. He was graduate of West Point and had been in the engineering corps during the war. He resigned and took service with the railroads, intending to follow railroading as a business, believing there was greater possibility in it for him than in the army, but he was killed after a long fight with a band of Mexican Indians.

In building the Texas Pacific road we went through an epidemic of cholera and one of yellow fever and were subject at every town and every county line to shotgun quarantines, and notwithstanding that most of the engineers were from the north, they all stayed on the work.

I remember in 1873 when we were rushing to close the tracks in Texas, coming from the east and west to save our land grant, the epidemic of yellow fever was upon us and every morning those of us who were at the end of the track could see numerous corpses taken

out of the working gangs and buried in the dump; it took a brave, determined man of great moral courage, who was under no obligations except that of duty, to stay and fight it out.

I remember one young engineer who was setting grade and centers for the track layers. He lived in the cars that housed the convicts that were laying the track, who, no matter how much they wanted to leave, could not; he went out on his work promptly every morning and could see in the number of convicts taken out and buried, the progress of the fever, and that it was only a question of time when it would have him in its grip. I thought it possible he might leave us, so one morning I walked out and spoke to him, asking him how he and his men were feeling. He said very quietly that they had considered the situation and they proposed to stay on the job until we connected the track, but he stated: "Then I shall start on the first train for God's country and never shall come back to this." I thanked him for his determination to stay and he stated he had been employed on the job for the season and he did not propose to run because some others had; he was a specimen of the engineers who went south with us. A great many of them had the yellow fever, some of them died, but they all showed an *esprit de corps* and an interest in the enterprise that would be a good object lesson to many who are on similar work today.

As soon as the tracks were joined, I gave all the engineers who had come from the north a leave of absence, but very few of them took advantage of it.

During the years from 1870 to 1874 the line was determined and located through to California. Work was commenced at San Diego and some 500 miles were built during that time in Texas, but the Jay Cook failure stopped us and it was not completed through to California until 1883 and today three of the great railroads of the country occupy the line that was intended at that time for only one. They are the "Texas Pacific," the "Southern Pacific" and "Santa Fe." It is a singular fact that the same engineers and the same foremen who had joined the tracks at Promontory Point in 1869 met on the plains at Seirra Blanco, Texas in 1883, and joined there the tracks that united the second continental line across the country, but under entirely different circumstances. There were no bands, no crowds, no speeches, and no champagne. It was simply the engineers and foremen of the track laying forces that shook hands at this great event and it created very little notice or comment.

There has been a general belief throughout the country that it was a very easy problem to build a railroad, and that the railroads were over-capitalized, which recent investigation has demonstrated to be untrue. In my travels I have seen men riding in a Pullman car that carried a valet, a maid, a porter, and a conductor, which these people generally kept busy all the time, look out of the window and express the opinion that it was easy work or virtually no work to build a railroad through the country they were passing, and make

comments on what it represented and what it should cost, and I often used to think as I listened to them that they should have had the experience of the builders; first as chief of a party to spy out a line, perhaps alone in an Indian country; then followed by the young engineer, carrying a rifle on one shoulder and a transit on the other, camping where his day's work ended; then the bold spirits who furnished the money to first construct the road, that would have probably to be carried ten or twenty years before it brought any income, and then the operating department who had to reconstruct it two or three times and put millions upon millions into it to bring its commercial business and the luxury of its transportation up to our date; then he would take an entirely different view of the enterprise.

I thank God for the criticisms of the past two years have finally aroused the railroad world to educate the people and demonstrate to them what the transportation of this country has cost in lives, labor and money, and what benefits it has brought to the nation.

THE RAILROAD SITUATION OF TODAY

Frank Trumbull, C. & S. R'y Co.

Presented, January 5, 1909.

Mr. President and Gentlemen of the Society :

I shall not attempt to deal with any technical phase of the railroad industry, and in saying this I am emboldened by a declaration which I find in the Constitution of your Society ; to-wit :

“This Society shall neither endorse nor recommend any individual or any scientific or engineering production, but the opinion of the Society may be expressed on such subjects as affect public welfare.”

The American railroad administration of today has abundantly demonstrated its ability to solve all engineering and mechanical problems, and we may rely upon it that the same American enterprise and valor which have gridironed the continent with shining bands of steel, will solve any technical problem that may be ahead of us for which money may be had.

I therefore proceed at once to engage your thought for a few minutes, if I may, upon what seems to me to be the great problem of the American railroad situation of today ; that is, how to satisfactorily settle the relations between private capital and the users of the railroads.

FOUR YEARS' RETROSPECT.

During the last four years the American railroad has been in a seething cauldron of publicity ; a good deal of refuse has risen to the surface and has needed to be skimmed off,—but I think I do not violate any confidence in saying that not all of it has come from the body of the railroad. Part of it seems to consist of political bacteria and defunct statutes which attempted to violate the voice of the people,—the Constitution which legislators had sworn to support. And in this connection, perhaps I ought, in passing, to say a word which has rarely been spoken in defense of the railroads, by pointing out the shame of putting them to the great cost of proving in the courts the unconstitutionality of statutes which ought never to have been enacted because they were never valid. In the last four years there has been much noise ; the air has been filled with shouts and cries, and more or less dust. Hysteria and virtue, although really not at all alike, became confused, and a very large percentage of the public absorbed the idea that the railroad highways are public property, forgetting that all of us are absolutely dependent upon private capital for the American railroad of today. Again, we seem to have been upon a storm-tossed ocean. Fortunate are we that through it all has run the Gulf Stream of our wonderful American resources. If it were not for that, we should all have been ruined.

We have survived, but the pity of it is to think how much better off we might be, if "We, the People of the United States," would, in financial legislation, railroad regulation and other matters, only exercise our wisdom as much as we do our power. Legislation has been restrictive, not constructive. There is very little in it, thus far, to help the railroad. Nearly everything seems to have been thought of, except provision for money or for improving credit so as to command cheap money. The country has been flooded with conflicting laws and still the cry goes up for more bureaucratic power and more statutes. It reminds me of an immigration meeting in Mississippi:

The court-house was filled with an assemblage of white people, and when the meeting adjourned an old darkey asked one of the gentlemen who came out of the court-house what the meeting was for. The reply was that it was an immigration meeting. "What is dat?" asked the darkey, to which the gentleman responded, "We want to get more white people from the north and east to settle here." Whereupon the darkey said, "Foh de Lawd's sake, Majah, dars moh white people in dis county now dan us niggahs can support!"

I admit there have been many evils in railroad administration, but I modestly affirm that there have been no more than in other lines of business. The railroad industry of this country is young and it acquired some children's diseases. Many people think the railroads would have recovered from measles, mumps and whooping cough without prescriptions from forty-seven varieties of doctors—forty-six states plus the Federal government. It has seemed many times that the railroad patient has been like the man who fell ill in some mysterious way. The consulting surgeons determined that an operation was necessary. They could not locate any definite malady, but they found five hundred dollars on him so they operated on him for that! Of one thing, however, we may be absolutely sure—that is that the law of compensation is always at work. If we have an excess of regulation, there is less of something else. It is entirely probable that if there had been no political regulation of railroads, the people of this country would have more roads, far better and safer roads, and a greater distribution of wealth than they have today. But I must not forget that, according to the subject assigned me, we are here not to look backward, but to look at the present, and then perhaps take a little look forward.

SOME CONTRADICTIONS.

From a mechanical and traffic standpoint the American railroad of today is one of the wonders of the age. I give one illustration only: Compare its splendid performance with a report I have here of the Northeastern Railway of England, which has a large mineral traffic. This report shows average contents of loaded freight cars

to be 5.72 tons, and average contents of freight trains to be 114.7 tons!

On the other hand, the American railroad situation in its political and governmental relations is a bundle of contradictions. If you were to engage your money in merchandising or manufacturing, you would no doubt be appalled if you should discover that some one entirely outside of your line of business could fix the prices at which you must sell your product, and that the burden of proof that the prices so fixed are confiscatory, is upon you,—and that you could not abandon your operations. Yet this is precisely what may happen if you invest your money in a railroad. The contradiction is that there are no reciprocal assurances in your behalf. Neither the State nor the Federal government will give you any financial aid, nor will they guarantee you anything, nor will they even protect you against competition, as France has long since been wise enough to do.

A second contradiction is that although there was a four years' war to prevent a division of this country, and although thereafter our American genius connected up remote sections of our common country, and although the work of the railroads has been splendidly national, the attempt to regulate them has been lamentably local and Lilliputian. I need only cite the conflicts between the enactments and rate-making of different states and those of the Federal government. We hear more or less these days about the "twilight zone" between the states on the one hand and the Federal government on the other; but for those who administer the affairs of a great railroad system, the phrase "twilight zone" is too polite a term. It is instead a jungle in which the wayfaring railroad man may easily lose his way, and possibly be actually devoured by "laws with teeth in them." We hear a great deal about the simple desire that the railroads shall obey the law; but who is wise enough to say what the law is, when only yesterday the Supreme Court of the United States left an important case unsettled, so far as it was concerned, because it was divided four to four. These uncertain and conflicting laws and changes in rates confuse the railroad manager more than the public has ever realized.

A third contradiction is the attempt, by anti-trust laws, to maintain the competitive idea alongside regulation, as if unrestricted competition were compatible with compulsory uniformity in rates and service. The President of the United States and other high officials have spoken in no uncertain terms concerning the absurdity of a situation like this, and yet thus far there is no relief.

A fourth contradiction is found in the great increase in cost of producing transportation without the corresponding increases in selling prices which have taken place in other kinds of business in which private capital is engaged. The erroneous impression seems to prevail that the supply of capital for the railroad industry is an inexhaustible reservoir, regardless of the compensation which it shall receive and the conditions under which it shall perform its work.

A fifth contradiction is the effort to connect up rate-making with physical valuations. If it will be a satisfaction to the politicians to have a physical valuation of all the railroads in the United States, and the people are willing to be taxed to pay the great expense of obtaining it, perhaps no great harm will be done; but I believe all of us here would concede that valuations by the ablest engineers, if separately made, would not agree, and that before such valuations could be finished, they would be out of date. Some of us probably think that for rate-making purposes the Government may as well be employed in making a physical valuation of farms and farm improvements in order to ascertain what is a fair price for wheat; or, for that matter, perhaps be as well employed in adding up car numbers. I know something of a piece of railroad out west, which in a great mining excitement was built through rocky and tortuous gorges, and with four per cent. grades hung upon the precipitous sides of awful mountains in a climate described by one of the inhabitants as consisting of three seasons,—July, August and winter. Later the boom evaporated and the business of the road got down to one train a day. In the low ebb of traffic, a brakeman one day “sifted” into the trainmaster’s office and asked for a job. The trainmaster put him through the catechism, and among other things inquired, “What would you think if you saw a train carrying green signals?” to which the applicant promptly responded, “I’d think business was picking up.” Now, can any of us tell what they would do in Washington with a physical valuation of a road like that? Its rates today are only about one-fifth what they were at first.

A sixth contradiction is the wide-spread desire to regulate capitalization. Now it may be that there have been abuses; but if one asks any of these critics what is the grievance to be remedied, great silence usually falls upon them, for they are unable to show any more relation between rate-making and either physical valuation or capitalization than there is between the price of a pair of suspenders and the physical valuation or capitalization of a department store. Railroads are continually importuned to make rates that will “move the business,” as in the case of the Western road just cited, and those parts of the United States which have the highest railroad capitalization have the lowest average freight rate. If you will look at the *American Review of Reviews* for the month of June 1908, you will find a very interesting article by Interstate Commerce Commissioner Lane on “Railroad Capitalization and Federal Regulation.” His program is a very simple one, and while pointing out that there should be some way of insuring that the proceeds of all railroad securities shall be actually invested in “acquisition of property, construction, completion, extension, or improvement of facilities, the improvement or maintenance of service and the discharge or lawful refunding of obligations,” he says,—

“Fundamentally, there is at present no inter-dependence of “capitalization and rate,—the latter is not in law, nor in rail-

“road policy, the child of the former,—though railroad men
 “have sometimes expediently urged the claim, and courts have
 “sometimes too kindly given it their nod of sanction.”

Also,

“The most potent kind of regulation is that which casts the
 “burden upon the individual to do the regulating himself and
 “makes him responsible to the law for dereliction; and the plan
 “for the regulation of capitalization here presented is founded
 “upon that theory,—to require the directors of the railroad
 “companies to make public announcement of their security
 “issues, to publish the objects for which such issues are made,
 “and be responsible for the use of the proceeds in the precise
 “and limited manner announced. This is far too modest a
 “program to please those who delight in elaborate methods of
 “procedure involving much filing of forms and petitions and
 “many hearings, appraisements, viséings, and solemn givings
 “of consent; and without question it is not nearly as thorough-
 “going a plan as others which have been devised. But the
 “simpler the plan is, the better, if it may effect its purpose.”

He further says that his program

“does not guarantee the prospective purchaser of the stock that
 “the stock certificate which bears a printed par value upon its
 “face does in fact represent property of the full value so de-
 “signed; *but this is not a duty which the Government for any*
 “*reason is bound to assume*, and I know of no motive arising
 “out of national policy which compels the assumption of such
 “responsibility,—certainly not at present.”

If our complex government shall control all future issues of rail-
 road capitalization, we may rely upon it that most of the new rail-
 road construction in this country, instead of being independent, will
 be fathered by existing railroad systems, because their established
 credit, whatever it may be, will be required.

RECONCILIATION.

Is it not evident that these contradictions never can be reconciled
 by untrained men? I believe that for the American railroad the
 time has gone by when illiterate men will be put in charge of mil-
 lions of dollars' worth of machinery and other property. We are in
 a new era. Railroading is rapidly coming to be a profession. We
 are necessarily in all things doing more and more specializing. Why
 not insist that the regulation also shall be in accordance with ethical
 principles and not determined by political expediency?

The great over-shadowing problem of reconciling private capital
 and the users of railroads, and the contradictions which I have
 mentioned, are the inheritance of this generation of railroad men;
 and I have no doubt that this generation, like all previous ones, will
 be equal to the task put upon it. Out of the painful processes of the

last four years, we have emerged with some gains. In the first place, the country now realizes that the one million, five hundred thousand employes and officers of American railroads are not surpassed in integrity by any other similar number of business men. During the four years, hardly a voice has been lifted to say this, and so I am glad to have this opportunity to raise my own in their commendation. In the second place, it is easier for shippers and railroad traffic men to be honest than it ever was before. The stoppage of rebates is a distinct gain, morally as well as financially. In the third place, it has been demonstrated, I think, that our Government *ought* always to be bigger than any corporation, or any man, or any set of men, and this is a good thing for us never to forget.

Already publicity has brought about a friendlier feeling between the people and the railroads, and along certain paths I have no doubt we shall find our way out of our difficulties, for the American people are *not* unfair when they understand a situation.

Upon one occasion I was making a trip over a division of road where there was no competition and where we therefore enjoyed one hundred per cent. of the business. There was an unexpected stop for something and a brakeman went to the rear to protect the train. Presently a wagon-load of girls came in sight. The brakeman took out his handkerchief and initiated a flirtation. Then discovering that I had seen the performance and evidently desiring to square himself, he said without hesitation, "If we make friends of these people they ride on our road." One could hardly convey better than that brakeman did to me, an idea which we should never abandon, namely, that one of the best assets a road can have is friends, and I suggest that probably our first duty is to keep in good humor and be considerate one for another. That involves and includes good service to the public, and nothing will help more to keep the public in good humor. The people of this country already have the lowest rates and the highest wages in the world. They are the best people in the world and are entitled to the best service in everything. I believe they should insist upon having the best railroads, and when they so insist, and realize that our population has thus far doubled every thirty years and will soon be one hundred million, and not very long after that one hundred and twenty-five million, and that our transportation necessities double faster than our population does, they will set about finding out what is necessary to obtain adequate railroads, and then we shall probably hear less about rates and more about efficiency and safety. When the people do this they will soon discover that it is no more disgraceful to make money in building railroads than in selling land or in merchandising or in manufacturing or in mining. They will also discover that although the courts have said railroad investors are entitled to a reasonable return upon a fair value, no court—not even that great tribunal, the Supreme Court of the United States—can finally say what is a reasonable return. This question would still be unsettled because we

have not yet gotten away from our dependence upon private capital. What is a reasonable return must be answered by the investor as well as by the commissions or the courts, because it always takes two to make a bargain, and money, like its human owners, will go where it has the best prospective reward and the greatest liberty. The people will find that what we need in this country is not more bureaucratic government by untrained officials with brief tenures of political office, or more power to commissions, but more responsibility upon boards of directors. It statutes are necessary to insure this, well and good; but if regulation is general in character and national in scope, is directed against oppression and discrimination, and designed to promote safety and efficiency and faithful accounting, the people will get better results from intelligent and honest directors than they will from the best governmental management which can be devised; and so long as the railroads are owned by private investors, those investors will doubtless insist upon their directors having more and more to do.

I am aware that there is a socialistic trend all over the world. There is more and more disposition to prescribe medicine for other people to take, but no amount of legislation will change the fundamental laws of the universe. The fact is,—notwithstanding our Declaration of Independence,—men are not created equal. It is a fine thing for all of us that they are not. There is a diversity of gifts; money-making is one of them, but a man may have the talent for making money and be totally unable to build a bridge or paint a portrait or lead an orchestra or an army, and if fortunes are acquired under the laws which we ourselves have made, why should we be envious? Unless a rich man hoards money like a miser, it is—if not alarmed—continuously at work for all of us, through the banks or otherwise, in spite of anything he can do, and the cheaper it can be had, the greater the economy to society as a whole. It is impossible to reduce everybody to a dead level, and how monotonous it would be if we could! We don't satisfy everybody even in our form of government, which we are prone to think is the best in the world. For example, at the last election six and a half million people did not get what they voted for. Part of them got what they really wanted, but on the face of the returns, six and a half million were disappointed, and yet the country goes happily on, apparently to greater prosperity than ever.

But how much happier and how much more prosperous we might be if there were not so much untrained meddling—if there were not so many brakes upon the wheels of our progress! A brake, we all admit, is a good thing in its place, but it has no *propulsive* power, and the efforts of the time to combine in one man or in any one body of men the four functions of prosecuting attorney, judge, jury and executioner must sooner or later give way. First, because it is un-American, and where such a condition exists, as Alexander Hamilton pointed out to the people of New York, "There is no liberty." Second, because it will not work practically.

Reconciliation of private capital and the users of railroads might, of course, be brought about by government ownership, because if there were a deficit the people could pay it in their taxes. Even then railroad rates could not be made mathematically consistent, for government is never mathematically consistent. For example, if I mail a letter to San Francisco or London, I pay two cents, and if you mail a letter to Evanston, you pay two cents. But nobody seems to want government ownership, although many people contend that that would be much fairer and more honest than government control of railroads without financial responsibility. Perhaps a middle ground may sometime be worked out by a profit-sharing arrangement, as in Chicago between the city and the street railway companies. That would have its advantages. Among the advantages would be cheaper money for railroads, if the government would guarantee a minimum return on agreed valuations. But of course this would be much more complex than to work out an arrangement with corporations like street railways, which do a single kind of business at one rate, instead of a business affecting every commodity of human consumption and stretching through forty-six states and two territories. However, I think there is food for thought for all of us in what has been accomplished here in Chicago, and the professional intellect present tonight may well think it over.

Finally,—while a man has as good a right to increase his fortune by investing in railroads as in any other manner, no matter what it may be, I believe we shall find a solution for some of the puzzles that beset us,—not through the gospel of tyranny on the one hand, nor the gospel of equality on the other hand, but through a gospel of stewardship. Let us all feel that although the acquisitive faculty is undoubtedly planted in the human breast for some wise purpose, we are not here primarily for personal aggrandizement. We are here for service, and the greater our talents or our wealth or our opportunities the greater our responsibility. We are trustees—for the users of our railroads for our employees, and for investors; and let us welcome all the additional responsibility which may be put upon us as directors or salaried officials. I am sure this sentiment will commend itself to all of you, because there is no body of men in the world which has a higher code of ethics and which has demonstrated personal fidelity in a higher degree than the Engineers of America.

IMPROVEMENT OF THE UPPER MISSISSIPPI RIVER

C. McD. TOWNSEND, M.W.S.E.,

Lieut. Colonel, Corps of Engineers, U. S. A.

Presented Nov. 4, 1908.

INTRODUCTION.

The works constructed in the upper Mississippi River afford excellent illustrations of the successful solution of many of the problems that arise in the improvement of non-tidal rivers. The obstacles at the Des Moines Rapids have been surmounted by a lateral canal. At the Rock Island Rapids a channel has been excavated through the rock composing the bed of the river and the slopes modified by submerged dams and wing dams, as effectively as in the celebrated improvement of the Iron Gate on the Danube. The stretch of river from St. Paul to Lake Pepin is an example of as successful a regulation of a river by wing dams and bank revetments as can be found on any river in Europe. Levees have been constructed which protect from overflow 220,000 acres of alluvial bottom lands, and harbors of refuge from ice and storms have been built.

The principal authors of these improvements are General Alexander Mackenzie, Chief of Engineers, U. S. A., who was for fifteen years in charge of the general improvement of the river, and Colonel Amos Stickney, Corps of Engineers, who was in local charge of the Des Moines Rapids Canal during its construction. Descriptions of their work are to be found scattered through the voluminous reports of the Chief of Engineers. These officers have now retired from active service, and it is considered a fitting tribute to them to compile the results of their labors in the following paper, which while it has been principally derived from the reports of the Chief of Engineers, has been submitted for criticism to the Assistant Engineers who efficiently supported them, and the writer acknowledges valuable assistance in its preparation from Messrs. C. W. Durham, M. Meigs, J. D. Dushane, W. A. Thompson, J. C. McElherne, S. Edwards and A. L. Richards.

As the river and harbor act of March 2, 1907, enlarged the project for improving this portion of the river, the close of the fiscal year ending June 30, 1906, becomes a suitable time to sum up the work done under the original project.

To fully illustrate the works of the district would require a series of drawings too voluminous for the purposes of this paper, and to fully describe them would make it of interminable length. Maps of the river on a scale sufficiently large to show the works of improve-

ment would form an atlas of about 80 sheets. The maps showing details of construction of the Des Moines Rapids Canal fill two large volumes, and drawings of the Rock Island Rapids are nearly as numerous. The stretch of river from St. Paul to Prescott has been selected to show the method of improvement adopted, and such other parts of the river only are described as illustrate some variation from the general methods adopted. At the Des Moines Rapids Canal drawings of the middle lock has been submitted as the type of lock construction, and a map of Rock Island Rapids has been prepared showing the work done under the various projects.

DESCRIPTION OF THE UPPER MISSISSIPPI RIVER.

The work on the Upper Mississippi River described in this paper extends from the Omaha bridge at St. Paul, Minn., to the mouth of the Missouri River, a distance of about 658 miles. At St. Paul the river drains an area of about 32,000 square miles and has an extreme low water discharge during the season of navigation of about 2,000 cubic feet per second. The extreme flood height recorded, that of 1850, is 19.7 feet above datum—the low water of 1864, and 20.0 feet above the low water of 1894, the lowest recorded stage that has occurred when the river was not frozen over. The discharge of the river has been measured at a gauge height of 17.5 feet and found to be about 85,000 cubic feet per second.

From St. Paul to Prescott, Wis., a distance of 29.7 miles, the river has an average low water slope of 0.544 feet per mile. From a survey in 1879, made prior to any systematic improvement of the river, the following elements of its regimen have been obtained: The least depth on bars, 1.0 feet below datum; the mean of least depth on bars, 3.2 feet; greatest depth in pools, 21.6 feet; the mean of greatest depths, 9.7 feet.

At Prescott the St. Croix empties into the Mississippi, with a drainage area of about 7,146 square miles. Due to the influence of St. Croix Lake, it discharges little sediment, and below the junction the average low water slope becomes 0.281 feet per mile. There is a still further reduction of slope as Lake Pepin (56 miles below St. Paul) is approached. On this stretch of river before its improvement was undertaken, the least depth on bars was 2.0 feet below datum; the mean of the least depths on bars, 5.4 feet; the greatest depth in pools, 19.7 feet, and the mean of greatest depths in pools 14.7 feet.

Lake Pepin has a length of about 22 miles; its greatest width is 2.6 miles. The slope through the lake at low water is inappreciable, and the extreme range of flood 14.8 feet. In its passage through the lake, the Mississippi deposits most of its sediment, and emerges comparatively clear at all stages. It there forms a junction with the Chippewa river, which at flood stages carries a large amount of sand

and drains an area of about 9,530 square miles. For two miles below the junction, the low water slope is 0.851 foot per mile. The slope then gradually diminishes. Below Winona (Mile 116) the river has the same average slope as between St. Paul and Prescott; above the mouth of the Wisconsin river (Mile 212) the average low water slope is 0.107 foot per mile.

The Wisconsin river, with a drainage area of 12,864 square miles, also brings large quantities of silt into the Mississippi river during floods, and the low water slope below the junction increases to 0.323 foot per mile.

Below the Wisconsin river the principal tributaries are the Rock river, with a drainage area of 9,692 square miles; the Iowa river, draining 12,358 square miles; the Des Moines river, 13,692 square miles, and the Illinois river, 27,963 square miles. Variations in slopes are found at the mouths of all these tributaries, but are most marked at the mouth of the Illinois, the average low water slope for ten miles above being 0.570 foot per mile, and for four miles below, 0.137 foot. The drainage area of the various tributaries is shown in Table I, and the low water slopes of the Main river on Plate II.

TABLE I.

Drainage Areas of Tributaries of the Mississippi Above the Missouri River.

TRIBUTARIES	Miles from Omaha Bridge, St. Paul	Right or Left Bank	Area: Square Miles
<i>Above Omaha Bridge, St. Paul.</i>			
Upper Mississippi (above the Minnesota).....	4	..	19,903
Minnesota	4	R	12,119
<i>Below Omaha Bridge, St. Paul.</i>			
Saint Croix	30	L	7,146
Trimbelles, Isabelle and Rush.....	43, 56, 61	L	379
Cannon	48	R	1,690
Chippewa	78	L	9,530
Zumbro	84	R	1,604
Whitewater and Indian Creek	99	R	521
Beef, Waumandee and Trempealeau (Mountain).....	88, 109, 121	L	1,428
Black and La Crosse	144	L	3,384
Root	148	R	1,823
Upper Iowa	170	R	1,375
Yellow	206	R	652
Wisconsin	212	L	11,835
Turkey	236	R	1,589
Galena	278	L	1,895
Maquoketa	296	R	2,209
Wapsipinicon	339	R	2,957
Rock	366	L	9,692
Iowa	411	R	12,358
Edwards	414	L	638
Henderson	437	L	1,227
Skunk	450	R	4,753
Des Moines	486	R	13,692
Fabius (and two creeks)	525	R	3,086
Salt	566	R	2,815
Cuivre (and two creeks)	615-620	R	1,607
Illinois	635	L	27,963
Total drainage area, square miles.....		..	159,897

The range of flood heights varies from 12.0 feet at the head of the Des Moines Rapids to 34.8 feet at Alton; the Alton gauge, however, is affected by back water from the Missouri river. Table II gives the distance, elevation of datum, lowest and highest stages and average slopes at the principal landings on the Mississippi river between St. Paul and the mouth of the Missouri river, the datum line being the low water of 1864 above Louisiana, and that of 1894 at and below that place.

The depths existing on the different stretches of the river before improvement will be found in Table III.

Measurements of the discharge of the Upper Mississippi river were made at a number of localities during the survey of the river in 1878 and 1879. The results are appended in Table IV. At St. Paul, discharge measurements have been made annually since 1890. The mean discharge curve resulting therefrom is shown in Plate III. From October, 1880, to October, 1881, a series of discharge and sediment observations were taken, under the direction of the Mississippi River Commission, at Prescott, Wis. (Mile 30); Winona, Minn. (Mile 116); Clayton, Iowa (Mile 219); Hannibal, Mo. (Mile 540), and Grafton, Ill. (Mile 636). The resultant mean discharge curves are also shown on Plate III.

The valley of the Upper Mississippi is narrow. The hills inclosing the valley have in general, steep slopes on the river side, so that the minor streams when in flood bring into the river large quantities of gravel and in some instances boulders of considerable size, which it is occasionally necessary to remove by dredging.

When the main channel of the river washes the hills on one side of the valley, there is usually found on the other side a minor channel termed a slough, connecting with the main channel by numerous cross sloughs. At low stages many of these sloughs are dry, but at medium or flood stages the alluvial valley contains numerous islands through which the main channel of the river winds, but loses considerable of its energy by the draft into the side channels. In its unimproved condition sand bars frequently formed in the channels having depths on their crests of less than $1\frac{1}{2}$ feet below low water. The channel was also obstructed by snags, boulders and ridges of rock extending across the river. The most noted of these rock ridges form the Rock Island Rapids and Des Moines Rapids.

The origin for distances on the river is at the Omaha bridge at St. Paul, the upper limit of the district, the datum for elevations is the Cairo datum of the Mississippi river, 21.26 feet below the mean level of the Gulf of Mexico at Beloxi, Miss. The local datum line is the low water of 1864 where known, and as computed from observations in 1877 at other localities from St. Paul to Louisiana (Mile 568); at and below Louisiana the low water of 1894 has been adopted.

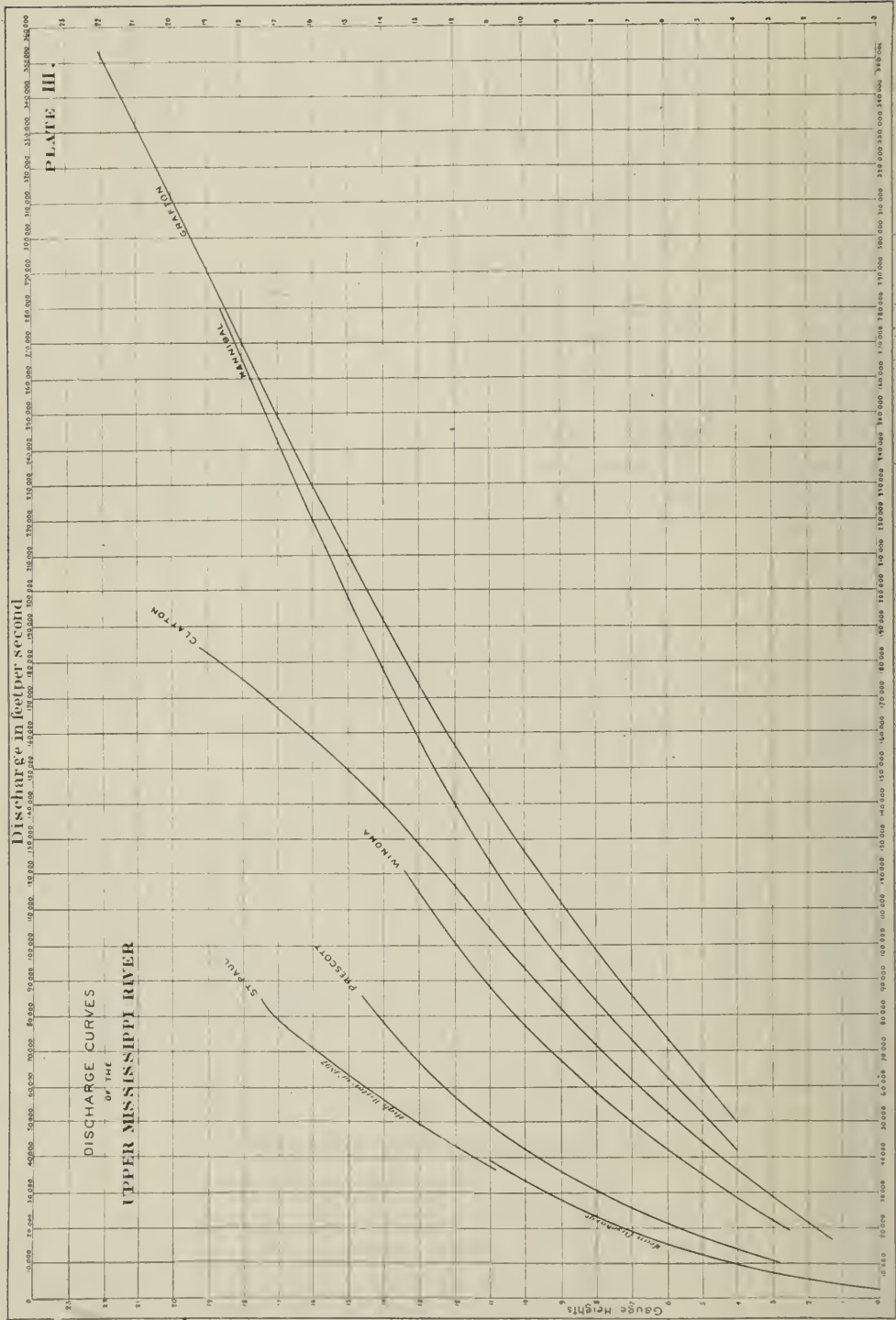


TABLE II.

Distance, Low Water Elevations, Fall, Slope, and High and Low Water Stages During Season of Navigation.

Upper Mississippi River, St. Paul, Minnesota, to St. Louis, Missouri.

LOCALITY	Distance from St. Paul Miles	Elevation of Datum, Low Water of 1864 Feet	Fall— Feet	Slope per Mile—Feet	Lowest Water Stages, 1878- 1906—Feet	Highest Water Stages, 1878- 1906—Feet
St. Paul (Omaha Bridge).....	0.0	706.02	.....	.....	.....	.....
St. Paul (Jackson St.).....	2.2	705.11	.....	.....	—0.3	19.1
Newport	10.3	700.15	5.87	0.570	.....	.....
Hastings	27.2	690.79	9.36	0.554	—0.5	18.0
Prescott	29.7	689.86	0.93	0.372	—0.7	.....
Diamond Bluff	40.9	686.71	3.15	0.281	.....	.....
Trenton	46.6	685.69	1.02	0.179	.....	.....
Red Wing	50.0	685.47	0.22	0.065	—0.3	15.3
Wacouta	56.1	685.03	0.44	0.072	.....	.....
Lake City	68.0	684.89	0.14	0.010	.....	14.9
North Pepin	73.5	684.85	0.04	0.007	.....	.....
Reeds Landing	77.3	684.64	0.21	0.055	—0.4	14.8
Wabasha	80.6	681.83	2.81	0.851	.....	16.3
Alma	88.0	676.26	5.57	0.753	.....	16.3
Minneiska	98.4	671.01	5.25	0.505	.....	15.1
Mount Vernon	100.0	669.75	1.26	0.788	.....	.....
Fountain City	108.2	665.42	4.33	0.528	.....	15.3
Winona	115.9	660.34	5.08	0.660	0.2	17.0
Homer	121.0	659.08	1.26	0.247	.....	.....
Trempealeau	126.9	655.66	3.42	0.580	.....	.....
Richmond	129.8	653.66	2.00	0.690	.....	.....
Dresbach	136.5	650.97	2.69	0.401	.....	17.0
La Crosse Wagon Bridge.....	144.2	646.48	4.49	0.583	0.2	16.0
Brownsville	152.6	642.61	3.87	0.461	.....	16.5
Warners Landing	158.7	638.52	4.09	0.670	.....	.....
Genoa	162.3	637.00	1.52	0.422	.....	19.0
Victory	169.3	635.51	1.49	0.213	.....	18.7
De Soto	174.4	633.96	1.55	0.304	.....	.....
Lansing	178.8	632.34	1.62	0.368	.....	19.6
Heytmans	187.3	630.80	1.54	0.181	.....	.....
Lynxville	191.5	628.79	2.01	0.479	.....	20.9
Johnsonport	202.0	626.10	2.69	0.256	.....	.....
N. McGregor Bridge	208.0	625.32	0.78	0.130	0.3	21.5
Wisconsin River	212.3	624.86	0.46	0.107	.....	.....
Clayton	218.8	622.76	2.10	0.323	.....	21.0
Glenhaven	225.6	620.79	1.97	0.290	.....	19.9
Cassville	236.5	615.88	4.91	0.450	.....	21.6
Waupeton	244.0	613.26	2.62	0.349	.....	.....
Spechts Ferry	251.8	610.29	2.97	0.381	.....	21.3
Dubuque	264.8	605.60	4.69	0.361	0.0	21.7
Bellevue	288.0	598.72	6.88	0.297	.....	20.5
Savanna	307.3	592.72	6.00	0.311	.....	19.8
Sabula	309.1	591.82	0.90	0.500	0.2	19.5
Lyons Bridge	324.7	587.08	4.74	0.304	.....	20.4
Clinton	326.8	586.43	0.65	0.310	0.2	20.5
Albany	331.2	585.42	1.01	0.230	.....	19.9
Cordova	342.0	583.21	2.21	0.205	.....	17.4
La Claire	348.1	583.11	0.10	0.016	.....	13.7
Hampton	353.1	575.58	7.53	1.506	.....	14.8
Rock Island Bridge.....	362.8	562.37	13.21	1.362	0.0	19.4
Buffalo	372.0	558.97	3.40	0.370	.....	.....
Montpelier	376.6	557.10	1.87	0.407	.....	.....
Fairport	382.0	554.79	2.31	0.428	.....	18.6
Muscatine	390.0	551.28	3.51	0.439	—0.5	17.4
Port Louisa	403.4	546.98	4.30	0.321	.....	15.5
New Poston	411.5	544.37	2.61	0.322	.....	16.2
Keithsburg	417.1	543.03	1.34	0.240	—0.3	14.9
Oquawka	429.2	537.03	6.00	0.496	.....	16.0
Burlington	441.6	531.25	5.78	0.466	—0.2	17.6
Dallas City	455.2	525.67	5.58	0.410	.....	17.5
Fort Madison	462.7	522.66	3.01	0.401	—0.3	16.5
Nauvoo	469.9	520.46	2.20	0.306	.....	14.0
Montrose	472.3	520.44	0.02	0.008	.....	12.6
Nashville	476.0	516.86	3.58	0.970	0.2	12.0
Keokuk	484.0	497.79	19.07	2.384	—0.7	19.6

February, 1909

TABLE II—Continued

LOCALITY	Distance from St. Paul Miles	Elevation of Datum, Low Water of 1864 Feet	Fall—Feet	Slope per Mile—Feet	Lowest Water Stages, 1878- 1906—Feet	Highest Water Stages, 1878- 1906—Feet
Warsaw	488.0	495.52	2.27	0.567	.....	....
Alexandria	488.6	495.21	0.31	0.516	.....	....
Gregory	495.0	492.29	2.92	0.456	.....	....
Canton	506.0	488.42	3.87	0.352	.....	....
La Grange	512.1	484.99	3.43	0.562	.....	....
Quincy	521.0	478.25	6.74	0.757	—0.3	20.3
Hannibal Bridge	539.1	469.52	8.73	0.482	—0.2	22.5
Saverton	546.6	465.95	3.57	0.476	.....	....
Mundys Landing	556.7	462.51	3.44	0.341	.....	....
Louisiana	567.7	456.77	5.74	0.522	0.0	20.8
Clarksville	577.4	453.42	3.35	0.345	.....	18.7
Hamburg	592.7	446.37	7.05	0.461	.....	....
Stag Island (head).....	600.7	442.70	3.67	0.459	.....	....
Hastings Landing	614.5	435.59	7.11	0.515	.....	....
Grafton	635.2	424.09	11.50	0.556	0.4	28.4
Elsah	639.5	423.50	0.59	0.137	.....	....
Alton	651.1	418.37	5.13	0.442	—0.2	31.4
Maple Island	654.1	417.14	1.23	0.410	.....	....
Missouri River	658.0	414.75	2.39	0.613	.....	....
St. Louis (Eads Bridge)	676.0	400.24	16.90	0.806	.....	....

In 1850, high water at St. Paul was 19.7; at Newport, 18.4. In 1851, at Camanche, 23.93; at Buffalo, 17.3. In 1869, at Trempealeau, 16.0. In 1870, at Red Wing, 16.6; at Wacouta, 16.6 (from Hayden's Geol. Survey, 1877).

In 1844, high water at Elsah was 31.8; at Alton, 34.8. In 1851, at Keithsburg, 16.2; at Oquawka, 17.3; at Fort Madison, 21.4; at Montrose, 14.1; at Keokuk, 20.9; at Warsaw, 21.9; at La Grange, 19.5; at Quincy, 22.6; at Hannibal, 21.9; at Louisiana, 22.3; at Clarksville, 21.9, and at Alton, 30.7. In 1870, at Hastings, 18.7, and at Moline, 15.0 (levels of C. W. Durham).

TABLE III.

Depths of Mississippi River, Derived from Survey of 1878-1879.

Miles from Omaha Bridge, Saint Paul	DESIGNATION	Year	Max. depth in pools. Feet	Min. depth on bars. Feet	Mean of max. depth in pools. Feet	Mean of min. depth on bars. Feet	Number of crossings	Average stage at time of survey Feet
2-30	St. Paul to Prescott.....	1879	21.6	1.0	9.7	3.22	39	4.3
30-56	Prescott to Wacouta.....	1878	19.7	2.0	14.7	5.43	23	0.8
77-108	Chippewa River to Fountain City.....	1878	24.0	1.4	11.7	4.3	34	2.2
108-144	Fountain City to La Crosse.....	1879	20.6	2.6	13.1+	3.96	34	1.3
144-179	La Crosse to Lansing.....	1879	29.0	3.1	18.6	6.9	38	1.6
179-212	Lansing to Wisconsin River.....	1879	22.8	2.4	18.7	5.07	21	2.6
212-265	Wisconsin River to Dubuque....	1878	33.0	2.7	17.5	4.57	39	2.5
265-307	Dubuque to Savanna.....	1878	24.1	1.2	14.8	4.38	27	2.9
307-348	Savanna to Le Claire.....	1878	19.4+	3.1	15.5	4.8	17	2.9
363-403	Rock Island to Port Louisa....	1878	16.6	2.2	12.2	4.61	21	2.4
403-442	Port Louisa to Burlington.....	1878-9	23.7	2.5	15.5	5.41	20	3.4
442-472	Burlington to Montrose.....	1878-9	30.6	2.7	18.3	4.81	22	2.8
484-521	Keokuk to Quincy.....	1878	29.0	1.9	16.6	4.08	22	3.1
521-553	Quincy to Cincinnati Landing...	1878	33.5	—0.1	14.0	4.7	14	3.1
553-593	Cincinnati Landing to Hamburg.....	1878	29.7	0.9	15.4+	5.1	26	2.5
593-635	Hamburg to Grafton.....	1878	20.9	1.2	15.8+	5.5	33	3.1

GENERAL IMPROVEMENT OF THE UPPER MISSISSIPPI RIVER.

The original project for the improvement of the Upper Mississippi was adopted in 1878, and proposed the contraction of the waterway by the closure of chutes, construction of wing dams, and revetment of caving banks, so as to obtain a navigable channel of a depth of

4½ feet at extreme low water, to be eventually increased to 6 feet. The datum adopted is the extreme low water of 1864, checked where interpolation has been necessary by the low water of 1894. At the various gauges this varies from 1.25 to 2.0 feet below the plane of the mean of low water during the seasons of navigation; but when the river is frozen over, gauge readings below zero are not infrequent.

TABLE IV.

Gauging Measurements on the Upper Mississippi, by the Humphrey and Abbot Method of Mid-depth Floats.

LOCALITY	Miles from Omaha Bridge St. Paul	Year	Stage Feet	Width Feet	Wetted perimeter Feet	Area Sq. ft.	Mean velocity per second Feet	Discharge per second cu. ft.
Frenchmans Bar.....	5	1874	5.8	.....	.....	.....	.....	20,091
Wabasha	81	1878	3.5	1,500	1,502	12,790	1,658	21,212
Winona	116	1878	1.3	1,476	1,477	8,651	1,856	16,061
Winona	116	1880	8.1	1,785	1,788	22,331	3,237	72,298
Johnsonport	202	1878	1.0	1,570	1,573	15,637	1,553	16,473
Below mouth Wisconsin Rvr. .	213	1878	0.96	1,237	1,239	16,161	1,270	20,527
Lyons	323	1878	3.1	1,736	1,737	23,227	1,615	37,512
Princeton	343	1878	1.1	2,087	2,088	21,599	1,284	27,743
Rock Island	363	1878	2.1	2,444	2,445	19,109	1,586	30,313
Rock Island	363	1880	18.4	2,737	2,740	60,880	43,456	251,348
Burlington	442	1879	7.2	2,406	2,410	34,791	2,975	103,536
Burlington	442	1879	0.7	2,333	2,335	19,749	1,414	27,929
Canton	506	1878	5.2	2,339	2,341	25,571	2,403	61,445
Hannibal	539	1878	1.5	1,100	1,102	17,086	2,267	38,741
Hamburg	593	1878	2.0	1,936	1,960	24,675	1,892	46,691
Hastings Island	615	1878	1.6	2,030	2,061	25,731	2,001	51,485
Grafton	635	1878	2.2	2,800	2,842	24,722	2,036	50,348

The width to which the river is being contracted is 400 feet from St. Paul to the mouth of the St. Croix river (Mile 30), 600 feet from the mouth of the St. Croix to Lake Pepin (Mile 56), 800 feet from Lake Pepin to the mouth of the Wisconsin river, thence to Rock Island Rapids (Mile 348), 1,000 feet, from Rock Island to Quincy (Mile 521), 1,200 feet, from Quincy to Louisiana (Mile 567), 1,300 feet, from Louisiana to the mouth of the Illinois river (Mile 631), 1,400 feet, and from the Illinois river to the Missouri, 1,600 feet.

The works of improvement, consisting of bank revetment, wing dams, closing dams and longitudinal dikes, are generally constructed of brush and rock. The bank revetment (Plate VIII) consists, below the water surface at the time of construction, of a mattress of brush fascines sunk in place by rip rap rock; above low water line, of a rip rap of 6 to 12 inches of rock. The width of brush mattresses varies from 20 to 60 feet, being affected by the stage of river at time of construction, and the depth of water. The fascines are preferably made of willow brush, which is found in large quantities on the islands and sand bars in the river, but where there is a local scarcity of willows, the use of other varieties of wood sufficiently straight to be bound into fascines has been allowed. Recent specifications require that fascines shall be made of live brush sufficiently trimmed and choked to form a compact mass twenty feet long and from

twelve to fifteen inches in diameter, and tied with bands of lath yarn or wire not more than four feet apart. When made into mats they are closely packed and secured at distances of 8 to 12 feet by pairs of binding poles joined by ties of lath yarn or wire about two feet apart. The fascines are laid with their butts pointed down stream. The early practice was to lay the fascines at right angles to the shore line, butts to the bank, but in this position on steep banks there was found a tendency of the stone covering to slip.

The mattresses are constructed on small flats having inclined ways upon them, which are locally known as "grasshoppers." The grasshopper (Plate VIII) is a small boat, the hull of which is about 2 feet deep, 14 to 22 feet in width, and 32 to 40 feet in length. On this hull are placed ways or skids running fore and aft, usually 4 or 5 pieces of scantling rounded and smoothed on the upper side. They are given an angle of about 30 degrees with the water surface, to facilitate launching the mat, and extend over the forward end nearly to the water surface. When a length of mat equal to the length of the ways has been constructed, the grasshopper is dropped down the river a distance of about twenty feet, a corresponding length of the mattress sliding into the water, and another row of fascines is then added, lapping the preceding row from four to ten feet. In this manner a continuous mattress is constructed along the bank to be protected. It has been found advisable to employ small binding poles, to give greater flexibility to the mat. In some portions of the river three or four good-sized willow brush are substituted for the binding pole, with advantageous results. The necessity of flexibility in the mat is not only to prevent rupture while sinking, but it is found that as soon as the mat is in place the river currents produce a scour at the toe of the mat, and unless it is sufficiently flexible to conform to this scour, it is undermined and slips farther into the river, producing a break in the revetment at the water surface.

The upper bank is graded to a slope of from 1 on 1½ to 1 on 3 before the rip rap is placed. In the upper portions of the river, where the banks are low, the work is done by manual labor. In the vicinity of the mouth of the Missouri, where the banks are higher and more sandy, economic results have been obtained by the use of a drag scraper operated by the steam engine on a pile-driver. It has been the practice on certain portions of the river to sink the mattress one season and allow the river itself to grade the upper bank during the next flood, and complete the work another season. This method of procedure is economical, provided the completion of the work be not too long delayed.

Wing dams (Plate VIII) are constructed for the purpose of contracting the width of the river at low stages. It was originally proposed to construct the dams in accordance with the practice on German rivers as described by Schlichting, giving them an inclination up stream, in straight reaches of 105°-110°, on concave banks, 100°-102.5°, and on convex banks, 90°-100°, and so locate them that their

axes intersect in the middle of the channel. They were to be spaced at 5-7 of channel width in straight reaches, $\frac{1}{2}$ the channel width on concave banks, and on convex banks the width of the channel. While in general this plan has been adopted, there have been numerous exceptions, particularly in the spacing of the dams, due principally to economic considerations. The heights to which the dams have been constructed are also variable. The present practice is to build them to a grade four feet above low water on the upper portion of river and six feet above low water below the Des Moines Rapids. In their construction a mattress containing a single layer of brush fascines, bound with three sets of binding poles, is first sunk the entire length of the dam, to prevent scour during the process of construction and to serve as an apron to receive the flow over the dam. This is covered with a layer of rip rap rock about six inches thick on the upper side and one foot to eighteen inches on the lower side. A second mat is sunk on this rip rap from ten to fifteen feet further up stream and covered with stone. Additional mats are similarly placed and covered until the required grade is attained, each mat being placed two feet further up stream than the one immediately below it. In filling deep holes the use of multiple mats is permitted, i. e., mats composed of several layers of fascines. To prevent the erosion of the bank, it is revetted 25 to 50 feet above and about 50 to 75 feet below the point where the dam abuts against it.

In dam construction a building boat is required. The building boat is held in position by lines extending to anchors, anchor mats, or piles, previously put in position, and a barge of brush placed along its upper side. A barge of stone is held about 20 feet below by lines extending to it, and between the building boat and rock barge is placed the grasshopper on which the mat is constructed.

The mats for dams are constructed with the fascines laid across the grasshopper, butts down stream. They are usually bound with three sets of binding poles securely tied with lath yarn or wire, usually at every third fascine. The length of the mat varies with the swiftness of the current and depth of water, but rarely exceeds 100 feet. Three quarter inch lines are attached to the binding poles over the tips about ten feet apart, and to the binding poles over the butts about twenty feet. After the mat is launched these lines are fastened on keels on the building boat. Care is required in sinking the mat to prevent the river currents from turning it over and dumping the load of rock. An excess of rock is placed on the upstream side of the mat, and the lines connecting it to the building boat are gradually eased off. In shoal water the up-stream edge of the mat is sunk to the bed of the river before the lines running from the butts to the building barge are loosened. After the mat is sunk, the rock is uniformly distributed over it, and the lines used in sinking it are then removed, having been originally attached with a turn to facilitate their removal.

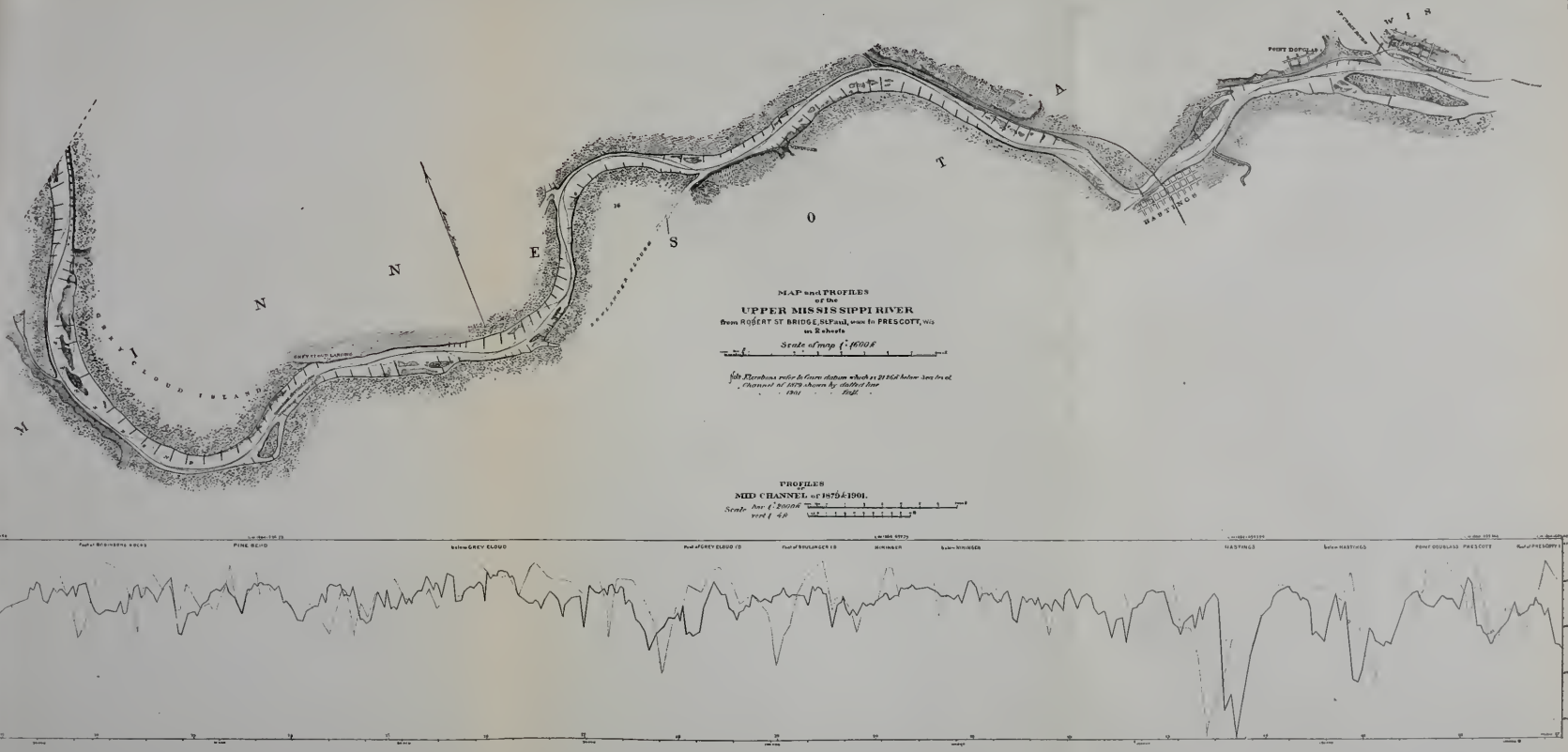
On the lower sections of the river the mat is constructed from tilt-

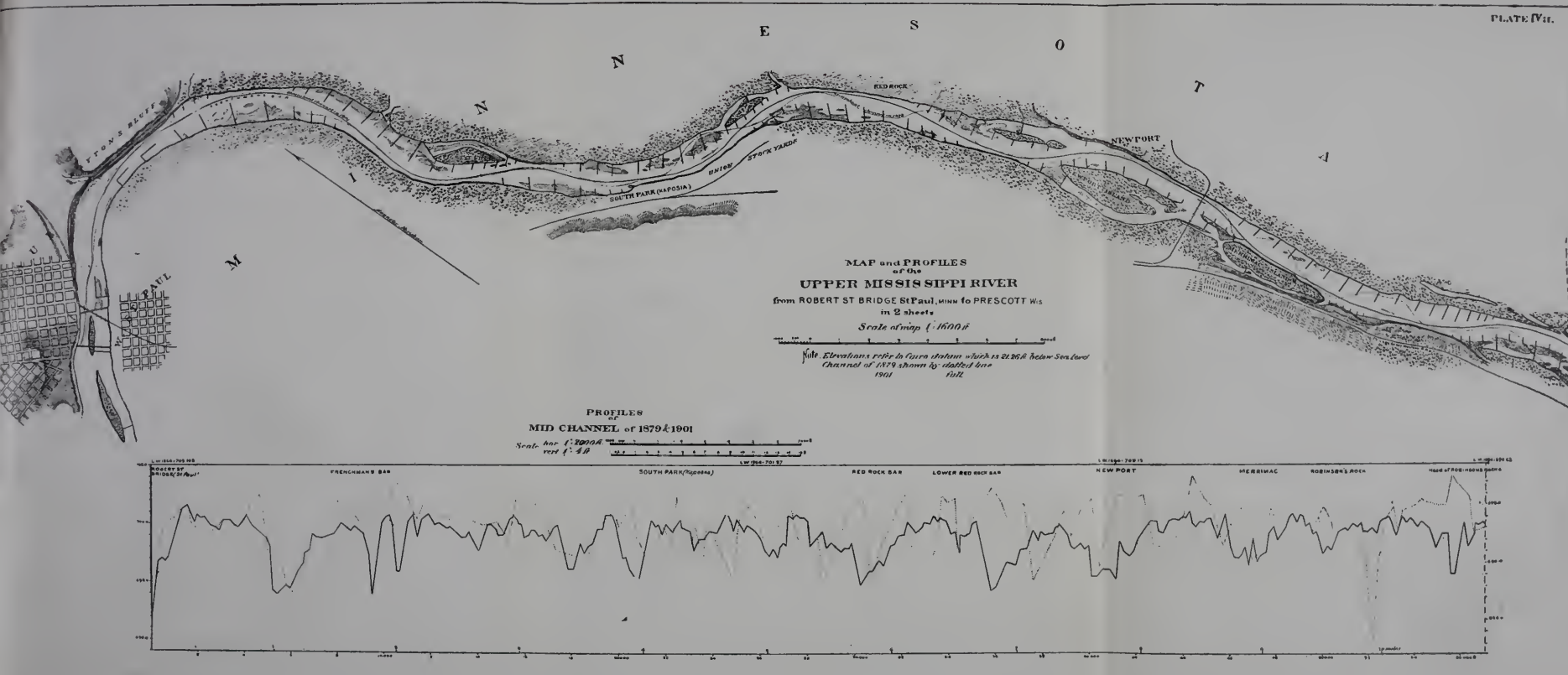
ing ways on the building boat, instead of from a grasshopper as above described. The building boat (Plate VIII) is 165 feet by 26 feet by 4 feet, and is equipped with two steam capstans and a set of 100-foot tilting ways. There are also hand capstans for handling by hand (if necessary) the anchor lines and the lines extending to the stone barge. The hand capstans are the No. B Providence, and are convenient as idlers when the lines are manipulated by steam. The steam capstans are of the single cylinder steamboat type. The tilting ways are made of 4-inch by 5-inch by 18-foot oak timbers. These timbers are set on edge about 8 feet apart and securely fastened together by a fore and aft stringer on the in-board side. Four feet from their outer ends they are set in a block one foot high, to which they are joined by a heavy strap hinge. To each alternate way is attached a 4-inch by 4-inch pine timber that extends down through a hole in the deck to near the bottom of the boat, when the ways are horizontal. A wire rope runs from the lower end of each of these timbers to a pulley on the deck above it, and is joined to a wire rope extending along the back of the ways to a pair of triple blocks, which are connected with the drum of one of the steam capstans. After the mat has been constructed, by winding on this capstan the inboard ends of the ways are raised and the mat launched.

The closing dams, which are employed to close chutes and side channels, are constructed similarly to wing dams, but usually contain more rock and the bank revetment extends a greater distance both above and below them. In long chutes, at low stages, a head of water exceeding four feet may exist on the dam; in such cases breaks have been not infrequent, and the experiment has recently been made of multiplying the number of dams in the chute so as to diminish the head on each and to increase the tendency to deposit sediment in the chute.

Longitudinal dikes are similar in construction to wing dams, but, as their name indicates, instead of being built approximately at right angles to the current, they extend approximately parallel to it.

During the first years of the improvement, pile and brush dams (Plate VIII) were built quite extensively in the river above Hastings (Mile 27). In constructing these dams, an apron was laid in the usual manner and piles were driven through it on the line of the dam. The distance between piles was about four feet. They were connected by a stringer at a height of about three feet above low water. Against this stringer brush fascines were laid side by side with their tips up stream and their butts extending over the stringer about one foot and bound to it with binding poles and wire. A small amount of rock was then thrown on the tips. Due to the small quantity of sediment in the upper river these dams have not been as successful as similar ones in the river below St. Louis have been. They were cheaply constructed, but after a few years they became so dilapidated that it was necessary to convert them into the ordinary brush and rock dam.





Where it has been necessary to dredge through gravel bars, the material removed has been frequently employed as a foundation for dams and topped with regular courses of brush and rock. The ferry dike opposite Hannibal (Mile 540) was built entirely of gravel, dumped at a 7-foot stage, and has required no repairs since its construction in 1883. A number of sand dams have been built above Lake Pepin with an hydraulic dredge, which deposits the body of the dam in such a shape that a single course of brush and rock completes it. Their cost is about one-half that of the ordinary brush and rock dam. They have usually been put in as intermediate dams of a series, and in such a location appear to be as durable as the ordinary type.

The proportion of brush to stone employed in constructing the different works has varied. The present practice is: for bank revetment, about 1 to 1; for closing dams, 1 of rock to $1\frac{1}{2}$ of brush; for wing dams, 1 of rock to 2 of brush. A number of dams have been constructed with the ratio of rock to brush 1 to 4. The repairs to these dams have been greater than to those containing a larger percentage of rock.

At the close of the calendar year 1905, there had been built 231.6 miles of dams and 188.6 miles of shore protection. The dams contained 3,630,234 cubic yards rock and 5,310,742 cubic yards of brush. The bank revetment contained 1,725,685 cubic yards of rock and 1,549,525 cubic yards of brush, an average of 1.73 cubic yards of rock to 1.55 of brush per linear foot. During the fiscal year ending June 30, 1906, 182,735 cubic yards of rock and 275,825 cubic yards of brush were expended on wing dams and revetments.

Due to the limited appropriations by Congress and the irregularity with which they have been made, the systematic method of improvement adopted on many foreign rivers could not be applied to the Upper Mississippi. It has been necessary to distribute the funds available over the entire district, first improving those bars having the least depth of water on them, and when these have disappeared, regulating the next shoalest bars. This process has been continued until at the present time bars restricting the channel to depths of less than $3\frac{1}{2}$ feet are seldom found.

When a partial improvement of the river is attempted, and the channel contracted over a single bar, there is usually a large movement of sand, which has a tendency to be deposited in the first wide portion of the river below, and which may form an obstruction as serious to navigation as the bar removed. This has been particularly true of the shoal river between St. Paul and Prescott, where it has been necessary to contract the river to a uniform width of 400 feet for the entire distance.

Plate IV is a map (in two sheets) of the river from the Robert Street bridge at St. Paul to Prescott (27.9 miles), with profiles of thalweg depths derived from surveys in 1879 and 1901, when the work was completed. The theoretical least depths on bars, measured

from the low water of 1864, has increased from 1.0 foot to 4.3 feet. The depth of 4.3 feet occurs on a bar in the vicinity of Grey Cloud (Mile 20), where the bed of the river is composed of gravel and bowlders, which the river currents have not sufficient force to readily scour and which may require removal by a dredge when the remainder of the river is sufficiently improved to justify it. On all other bars, low water depths exceeding $4\frac{1}{2}$ feet have been obtained. The work cost \$671,798, or \$22,293 per mile.

From Prescott to Lake Pepin (26 miles), the river has been improved in a similar manner, and the least depth on bars at low water has been increased from 1.8 foot to 4.7 feet. Due to the gentle slope and the resultant gentle current on this portion of the river, a uniform contraction of the channel to the width of 600 feet prescribed by the original project has not as yet become necessary. The cost of the improvement has been \$338,220, or about \$13,008 per mile.

The river empties into Lake Pepin through a delta formation (shown on Plate V), which may be compared to that at its mouth, and a bar is found in the lake similar to that existing in the Gulf of Mexico. In 1888 this bar shoaled to such an extent as to cause Lake Pepin to become temporarily the head of navigation. The project for improvement contemplates the closure of all side channels from the main river and the extension of the river channel across the bar to deep water in the lake by means of longitudinal dikes or jetties. Many of the side channels have been closed, and there has resulted therefrom such a deepening of the bar that the contraction of the channel across it has not as yet been necessary.

As above St. Paul navigation is impeded by the Falls of St. Anthony and the rapids below them, and the river empties into Lake Pepin a practically level body of water, the portion of the Mississippi river between St. Paul and Lake Pepin may be considered as an independent stream whose improvement has been completed in accordance with the original project. Attention is invited to the fact that this improvement has been accomplished without that dangerous disturbance of the original slopes of the river, which has been observed in attempts to regulate numerous European streams.

Below Lake Pepin while there are long stretches of channel that have been similarly improved, there are interspersed portions of the river where no work has been done. In those portions of the river where the channel has been contracted as satisfactory results have been obtained as in the river above, but in the unimproved portions new bars have frequently formed, or the original bars shoaled, so that the practical results of the expenditures thus far made have increased the navigable depth of the 650 miles of river under improvement from $1\frac{1}{2}$ feet at extreme low water to 3 feet.

The cost of the work in the river, divided into sections, is shown in Table V.

The only marked exception to the methods of work is on the section of the river above Alton, shown on Plate VI, where longitudi-

nal dikes have been constructed similar to those on the Rhone river, described by M. H. Girardon in a paper on the Regulation of Rivers at Low Water, read before the Vieme Congres International de Navigation Interieure La Haye, 1894. These dikes are given an elevation of three feet above low water at their centers, which elevation gradually diminishes to low water at their ends. They are connected by wing dams that have the same elevation at their outer ends as the dike has at the point of junction and gradually increase to an elevation of five feet above low water at the bank.

The extent of the improvement is indicated by the profiles. These longitudinal dikes were completed in 1897, and have since received only minor repairs. The last survey of this section of the river was in 1901, and it is probable they had not then produced their full effect. The chief objection to their employment is their cost. If the channel can be forced against the river bank, the bank can be revetted cheaper than an artificial bank can be constructed in mid-stream. The wing dams are essential to either method. It is to be also noted that the channel of the river, instead of impinging on the longitudinal dike at Dresser Island (Miles 646-647), follows the opposite shore, and the dike exerts no influence upon it, the connecting wing dams having produced the necessary contraction. The longitudinal dikes must conform to a certain curvature of the river to produce their maximum results. As this curvature varies with the slope, discharge, width of channel and character of bed, it can not always be determined with accuracy. The location of the channel can be rectified with the abandonment of less work with wing dams than with longitudinal dikes. The river has sufficient energy to maintain a channel of greater depth than $4\frac{1}{2}$ feet required by the project, and the result desired can be obtained by the wing dams without recourse to the connecting longitudinal dikes whose construction in general can be deferred until a further development of the channel is desired. There are, however, special cases where the employment of longitudinal dikes is economical.

On Plate VII is shown the effect of the closure of side chutes upon the main channel of the river. In the vicinity of Canton the bed of the river is composed of gravel, bowlders, and other glacial drift, on which is superposed sand bars brought down by river floods. Canton and Smoots chutes were closed by closing-dams in 1879; the area of cross section below low water of Canton Chute at the location of the dam was, in 1878, 4,566 square feet. Comparative cross sections of the river, from surveys of 1878 and 1898, taken at random, are shown on the drawings.

On other stretches of the river, where similar contraction of the low water channel has been attempted, but where the soil of the bed is composed of sand instead of glacial drift, it has been necessary to revet the banks extensively, so as to prevent any further widening of the river.

TABLE V.

Net Expenditures on Various Sections of the River, Harbor, Levees, etc., Between Minneapolis and the Missouri River, from Commencement of Improvement to June 30, 1906.

LOCALITY	Distance Miles	Amount	Per mile
St. Paul to Minneapolis.....	..	\$ 59,113.46	\$.....
St. Paul to Prescott.....	30	671,798.35	22,393
Prescott to Lake Pepin.....	26	338,219.92	13,008
Foot of Lake Pepin to Alma.....	11	467,503.77	42,500
Alma to Winona Bridge (Chicago and Northwestern)	28	790,102.75	28,218
Winona Bridge to La Crosse Bridge (Chicago, Milwaukee and St. Paul).....	28	805,780.58	28,778
La Crosse Bridge to McGregor Bridge.....	64	667,672.80	10,437
McGregor Bridge to Dubuque Bridge (Illinois Central)	57	489,795.68	8,242
Dubuque Bridge to Clinton Bridge (Chicago and Northwestern)	62	451,810.48	8,900
Clinton Bridge to Le Claire.....	21	39,830.24	1,897
Rock Island Rapids.....	14	669,994.94	.....
Rock Island Bridge to Keithsburg Bridge.....	55	377,859.20	6,870
Keithsburg Bridge to Nashville.....	59	934,077.95	15,832
Keokuk Bridge to Quincy Bridge.....	37	604,700.18	16,343
Quincy Bridge to Clarksville.....	56	1,086,951.96	19,410
Clarksville to Cap au Gris.....	37	915,199.56	24,735
Cap au Gris to Illinois River.....	24	441,582.26	18,399
Illinois River to Missouri River.....	23	440,659.58	14,800
Total	..	\$10,252,653.66	.....

THE DES MOINES RAPIDS CANAL.

The Des Moines Rapids extend from below Montrose, Iowa (Mile 472), to Keokuk, Iowa, 61,550 feet, measured by the steamboat channel, and 60,334 feet, or 11.4 miles, measured between gauges. The total fall at low water is 22.65 feet.

The first project for the improvement of the Des Moines Rapids was submitted by Lieut. R. E. Lee, Corps of Engineers, U. S. Army, in 1837, and contemplated the improvement of the natural channel by the excavating of rock. Prior to the Civil War, about \$350,000 had been expended on this project, and, as nearly as can be ascertained, about 25,000 cubic yards of rock excavated.

In 1867, a Board of Engineers was convened to further consider the subject, which recommended the improvement of the Rapids by the construction of a canal from Keokuk, Iowa, to Nashville, Iowa, 7.6 miles; the upper 3.4 miles of the rapids to be improved by excavating a channel 200 feet wide and 5 feet below the low water of 1864, at an estimated cost of \$2,530,000. Work was begun October 8, 1867, and the canal opened for navigation August 22, 1877.

The canal is 7.6 miles in length and extends along the Iowa shore from Keokuk to Nashville. The width proper is 300 feet in embankment and 250 feet in excavation, but owing to the irregularity of the shore, it stretches out in places to a width of 500 to 600 feet. The maximum depth is 8 feet, and the minimum depth 5 feet. The fall at low water is 18.75 feet.

The embankment inclosing the canal varies from 60 to 90 feet in width at bottom; it has a slope of $1\frac{1}{2}$ horizontal to 1 perpendicular, and is from 16 to 27 feet in height. It contains in the aggregate

a rip
wide

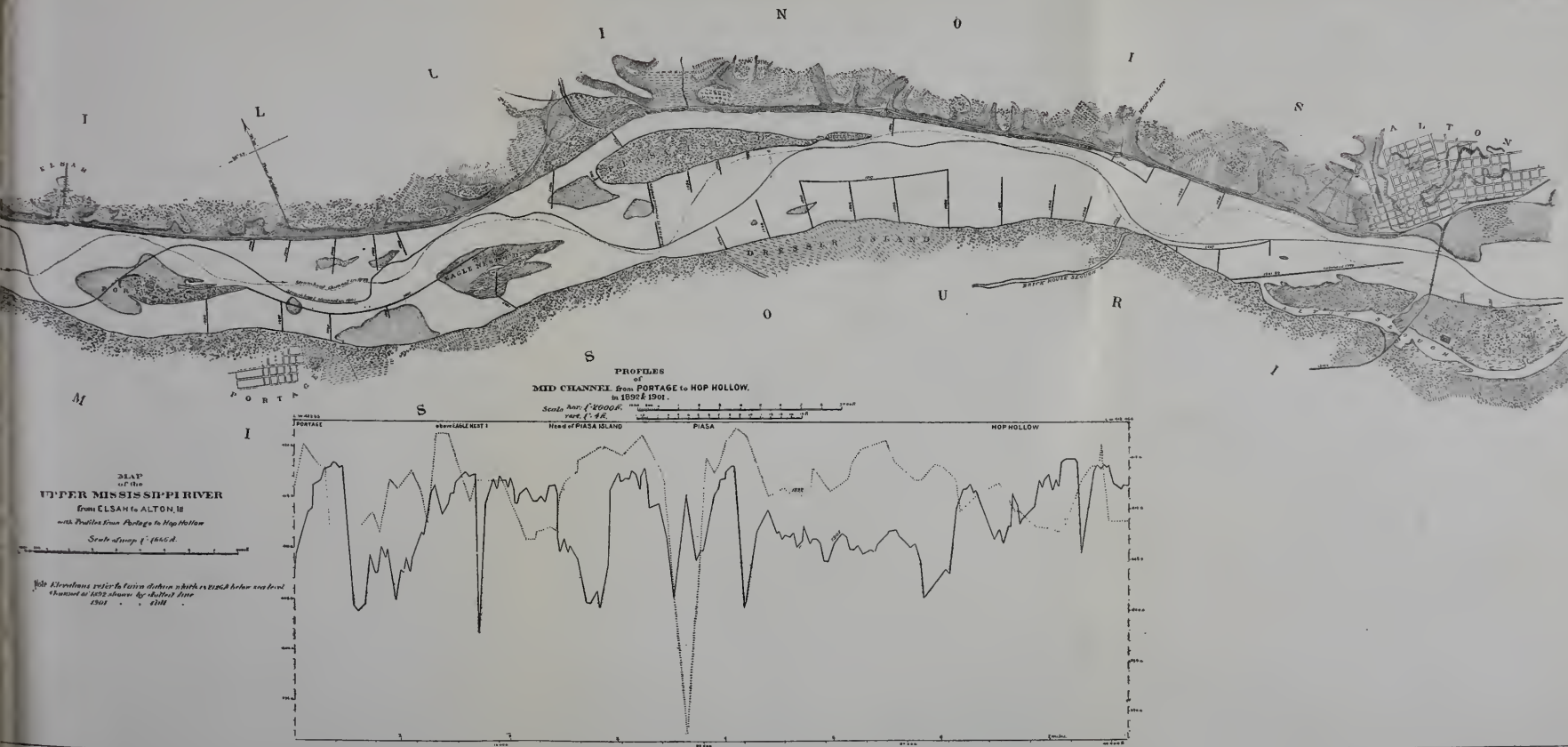
5,653
there
cubic
trose
ap-

lift
and
foot.
niles
bove
1.09
t, at
ubic
each.

ralls,
iber.
end,
the
er is
feet
sets,
y be
nilar

pper
t on
e on
shed

nery
ngi-
be-
ulic
ting
oke
with
the
lley
er a
tes,
also
and
hen



884,325 cubic yards of earth and is protected on both sides by a rip rap wall containing 111,667 cubic yards of rock. It is 10 feet wide on top, with a macadam covering of 2 feet in thickness.

There have been excavated from the prism of the canal 406,653 cubic yards rock and 857,775 cubic yards earth. In addition there have been excavated from the channel of the river 97,500 cubic yards rock; this includes the excavation of the chains at Montrose and Nashville, the channel intervening (3.4 miles), and the approaches to the Guard Lock and Lower Lock.

There are two lift locks and one guard lock, also used as a lift lock at high stages, each having a lock chamber 350 feet long and 80 feet wide at top, with a batter to the walls of $\frac{1}{2}$ inch to the foot. The Lower Lock is located at Keokuk, the Middle Lock $2\frac{1}{2}$ miles above, and the Guard Lock at the head of the canal, 7.6 miles above the Lower Lock. The lift of the Lower Lock at low water is 11.09 feet, of the Middle Lock is 8 feet, and of the Guard Lock 9 feet, at extreme high water. The lower lock contains about 14,000 cubic yards of stone, and the middle and guardlocks about 8,000 each. The details of lock construction are shown on Plate IX.

The locks are filled by means of culverts back of the lock walls, one on either side, with lateral openings into the lock, 8 in number. These culverts are 8 feet wide and 7 feet high at the upper end, diminishing to 3 feet 3 inches by 4 feet at the lower end, and the openings into the locks are 3 feet by 3 feet 10 inches. The water is admitted to these culverts by means of sliding culvert gates, 3 feet by 5 feet 10 inches, four on each side. There are also wickets, operated by hand, in the upper gates, by which the locks may be filled through the gates themselves. The lock is emptied by similar culverts and wickets at its lower end.

The lock gates are of wood, planked originally on their upper face. The lower gates of the lower lock, which are the heaviest on the improvement, weigh 110,000 pounds each. The gates close on miter sills and are suspended by means of heavy iron rods attached by swivels fastened to the top of large iron columns.

The culvert and lock gates are operated by hydraulic machinery designed by Major (now General) Amos Stickney, Corps of Engineers, who was in local charge during construction. In a well behind the recess of each lock gate is placed two vertical hydraulic cylinders: one for operating the lock gate, the other for operating the culvert gates within the recess. The pistons have a stroke slightly exceeding 6 feet. The culvert gates are provided with wrought iron stems extending about 16 feet above the gates. To the top of each stem is attached a wire rope which passes under a pulley on the lock wall over the entrance to the culvert, thence under a pulley near the hydraulic cylinder for maneuvering the culvert gates, and is connected to the upper end of its piston rod. A chain also passes over these pulleys and is attached to both the piston rod and to the gate stem at a distance of about 9 feet below the top. When

water is introduced at the upper end of the hydraulic cylinder the piston and rod descend, a pull is produced on the chains, the wire ropes play out, and the gates rise. Reversing the pressure causes a strain on the wire ropes, while the chains are loose, and the gates are lowered.

The maneuvering of the lock gates is similarly accomplished. In the original plans, one chain was attached to the side of the lock at a distance of about 33 feet from the quoins, and another to the miter sill at the same distance; these chains passed to sheaves under the gates at the same distance from their heel posts; thence vertically upward over sheaves on top of the gates; thence along the axes of the gates to the heel posts by a $\frac{1}{2}$ -inch wire rope, and thence over multiplying sheaves to the piston rods; but as the length of the piston stroke is only 6 feet, multiplying sheaves are used to increase the pull of the piston stroke. The sheaves multiply the piston stroke by 7. As the chain pulling across the chord of the arc whose radius is 33 feet would introduce a troublesome slack in the chain at most places, an angle iron segment is provided, around which the chains pass and which keeps them (between the wall and bottom of gate) always in a curve of 33 feet radius, thus obviating slack.

For the lower gates this system did not work satisfactorily. The chains, constantly fouled by the drift traveling along the bottom of the lock, would not run readily through the sheaves. Mr. M. Meigs, U. S. Civil Engineer, proposed the spar shown in the drawings, in broken lines, and which is applied to the lower gates at all locks. This spar is an I-beam, one end of which is attached to a pin on the gate, and the other end runs on a track on the lock wall. The wire ropes are connected to the opposite ends of this spar and are attached to the same multiplying sheaves as in the old apparatus, and as the hydraulic piston ascends or descends, the gates are, by the spar, opened or closed.

Connecting with the ends of each hydraulic cylinder are two 2-inch pipes, which extend to the engine house. The engine house is a stone structure 27 feet 4 inches square, and contains a pump (operated by an engine of 25 to 30 horse power), the necessary boilers, and a valve for controlling the flow of water to the hydraulic cylinders used in operating the lock gates and culvert gates. Underneath the house is a cistern 8 feet in diameter, for storing water. A 6-inch pipe extends from the cistern to the pump and a 3-inch pipe from the pump to the controlling valve. One controlling or distributing valve controls the flow of water to all the hydraulic cylinders that operate the gates, which is so arranged that when the valve is set to move a gate, the course of the water is from the cistern through the pump to the chest of the controlling valve, thence through a compartment to the pipe leading to one of the hydraulic cylinders, the water on the other side of the piston is forced back to a second tube in the compartment, thence under a sliding D valve to the tube connecting with the cistern. By means of this device a single operator

can handle the massive gates and wickets with ease and precision. The time required for opening or closing a pair of gates is about one minute; for filling or emptying the lock about three minutes.

The faults of this system are: The vertical position of the hydraulic cylinders in the wells requires them to be submerged, either wholly or partially, when the canal is full, making repairs and attention difficult. The scheme of chains under water, passing over submerged sheaves in the bottom of the gates, is bad. The chain fouls drift, trailing ropes, etc., and in case of breakage or wearing out cannot be repaired without draining the canal. The space is too confined under the gate for a diver to be able to do effective work. The 29 years in which these locks have been operated emphasize the fact that all lock machinery should be kept above water if possible, or, if that is not possible, should be contrived so that it can be hoisted out for repairs with the least possible difficulty and without having to drain the canal. Under water machinery cannot be lubricated nor be given proper inspection and care. The culvert gates work well and the spars for operating the main gates give good satisfaction, as all parts are above water and readily accessible. Theoretically the application of the power to the top of the gate is bad, but in practice it does not twist the gate in any injurious manner, and its advantages greatly outweigh any theoretical defects.

In order to control the surplus water carried into the canal by numerous streams entering therein during their frequent floods, it became necessary to build sluices around the locks. These were not included in the original plans, and have materially increased the cost of the work. The dimensions of these sluices are as follows: At the lower lock, 18 feet high, 16 feet 2 inches wide at the bottom, and 25 feet $1\frac{1}{4}$ inches at the top. At the middle lock, 15 feet high, 17 feet $7\frac{1}{4}$ inches wide at bottom and 25 feet $1\frac{1}{4}$ inches on top. At the guard lock the sluice used as a feeder is in the outside embankment just below the lock. It is 19 feet high and 38 feet wide. All the sluices have six openings, 3 by 6 feet, with gates at the head, the lower ends being open.

The work on the canal was delayed by inadequate appropriations, and heavy losses were sustained on account of high water, overflows and natural waste. It was opened for navigation in 1877, but work on the original project continued to 1880, at which date it had cost \$4,155,000, divided as follows:

Lower Lock and sluice.....	\$725,000.00
Middle Lock and sluice.....	470,000.00
Guard Lock and sluice.....	360,000.00
Excavation and embankment.....	1,900,000.00
Channel from Nashville to Montrose and upper and lower entrances to canal.....	475,000.00
Right of way, engineering expenses, etc.....	225,000.00

\$4,155,000.00

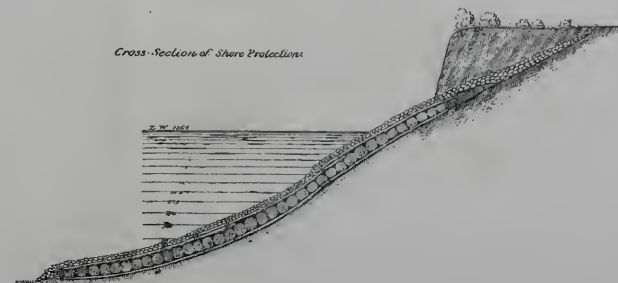
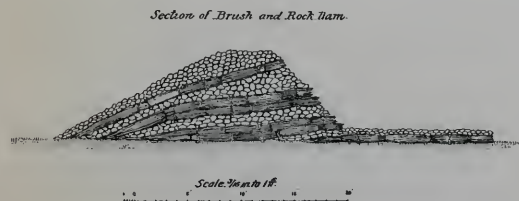
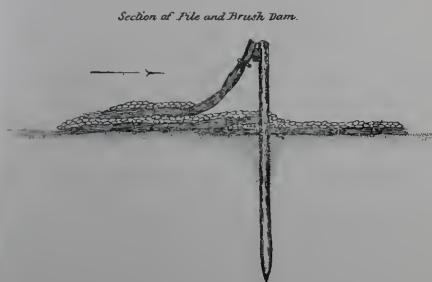
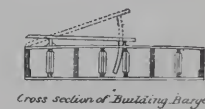
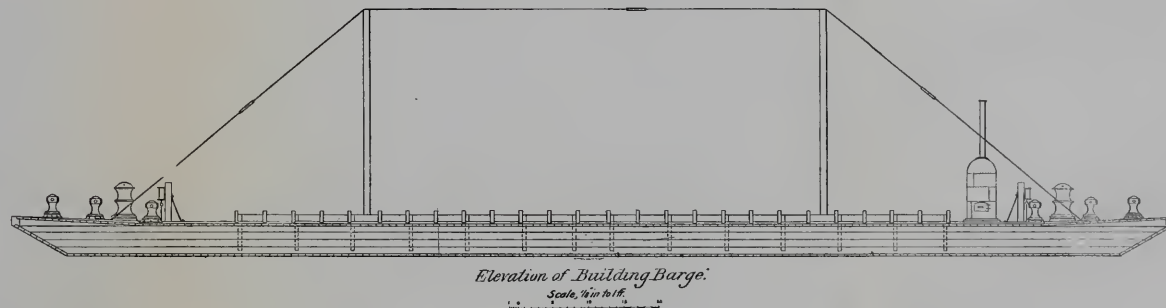
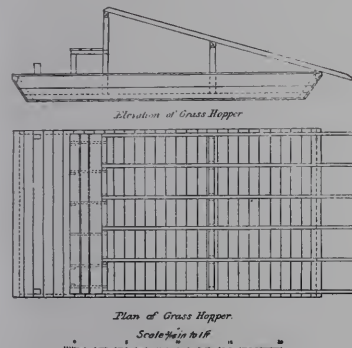
After the canal was in operation, several modifications of the original plans were found advisable. At both the upper and middle locks the lock walls were raised four feet, to prevent steamboats' guards from overriding the walls when the lock was full, and from catching on the wall as the lock was being emptied. A boom was built connecting the lower lock with the pivot pier of the Keokuk & Hamilton Railroad bridge 800 feet below, to facilitate entrance into the canal. Four cribs were constructed above the guard lock, supporting a floating boom, to aid boats entering that lock. A number of piers were built to mark the channel between the guard lock and Montrose, and this channel was widened at bends. An office building, machine shop and store houses were also erected, and a dry dock built.

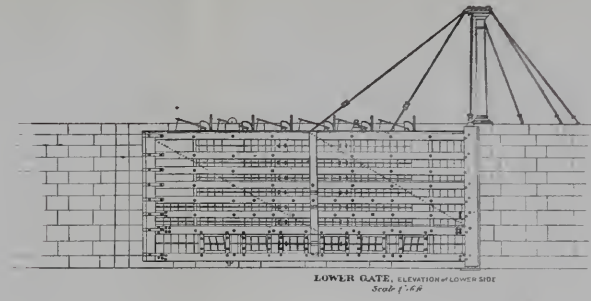
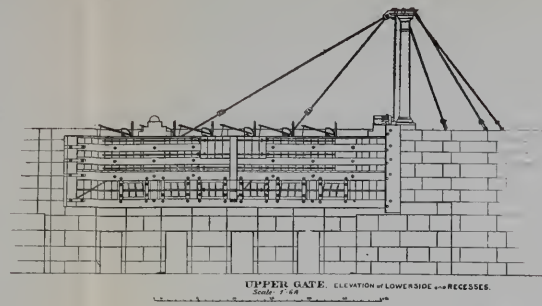
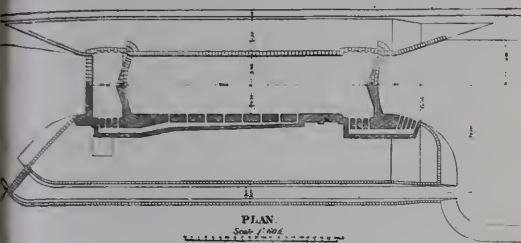
While the sluices around the locks discharge the waters of two large creeks and several small ones that empty into the canal, it was found that large quantities of sediment were deposited from them, which had to be removed by dredging. To reduce this dredging to a minimum, sluices were placed in the river bank of the canal opposite the two larger streams, which could be opened when the streams were in flood and the river was low, by which means much of the sediment was discharged in the river. The sluice at Sandusky has five openings, 4 feet by 5 feet, fitted with vertical balanced gates, which are operated at the top of the wall by gearing and a small hand capstan. The cost was \$11,851.33. The discharge from Price's Creek is controlled by a sluice with four openings, which was built in connection with the dry dock.

To June 30, 1882, there had been appropriated for the canal, \$4,574,950, which includes not only the cost of construction but also that of maintenance and repairs from 1877 to 1882.

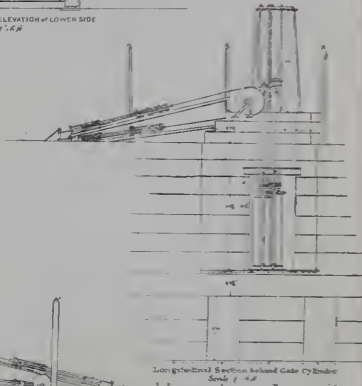
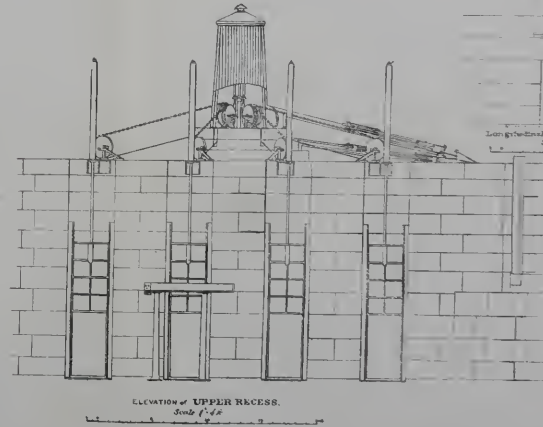
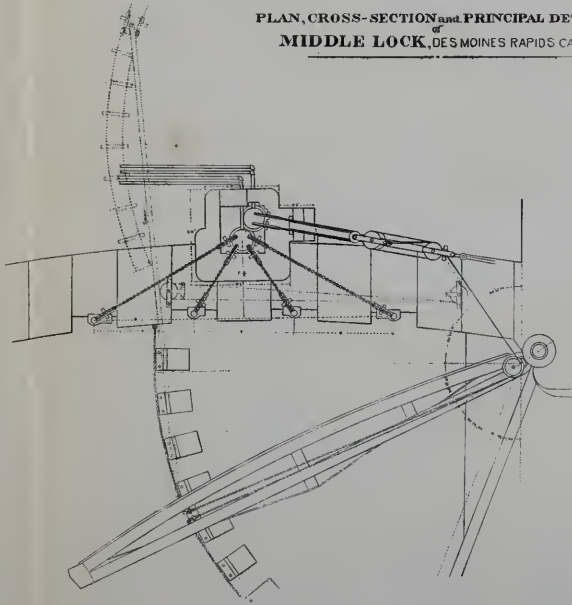
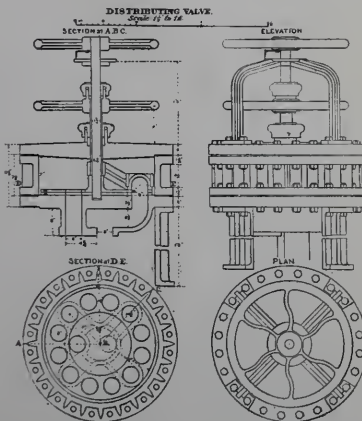
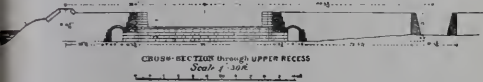
Repairs and Maintenance. A few days after the canal was opened for navigation the miter sills of the lower and middle locks were lifted from their position by the water pressure beneath them. This disaster was caused by faulty work of construction. Both locks were built by contract, and after the accident it was found that the holding-down bolts provided in the plans had not been properly put in. In some cases dummies had been used, and in others the lead which was supposed to fill the holes in which they had been inserted merely formed a collar near the surface of the stone and the bolt was consequently loose in the hole the greater part of its length. The canal was drained, 1¼-inch screw bolts put down through the miter sills, and sulphur used for fastening the bolts. While this has been effective in holding the miter sills in position, the bond of the stone having been broken by the accident, there is still some leakage through the joints of the masonry, though not enough to impair the efficiency of the lock.

The stone of which the masonry of the canal is constructed is a magnesian limestone, which occurs on both sides of the river in this vicinity. This stone varies in quality, and while the same class of





PLAN, CROSS-SECTION and PRINCIPAL DETAILS
of
MIDDLE LOCK, DES MOINES RAPIDS CANAL



material was supposed to have been placed in the locks—much of the stone coming from the same quarry—a marked difference is now evident. In the chamber of the guard lock, which was built by day labor, only two or three stones have disintegrated to such an extent as to require replacing; while in the lower and middle locks, which were built by contract, the deterioration has been much more extensive. A similar disintegration has also occurred in the pier of the guard lock at the low water line. A much greater seepage is observed through the walls of the locks built by contract than through those of the guard lock, and while it is possible that greater care was exercised in selecting the stone for the work done by day labor than for that done by contract, it is believed that the principal cause of the disintegration arises from loose joints in the masonry, which retain sufficient water to keep the stone wet until it is acted on by freezing weather.

In the chamber of the guard lock the portions of stone found defective were cut out and new stone inserted. In making repairs to the pier head of the guard lock and the masonry of the middle and lower locks, a rich Portland cement concrete was used, composed of two parts of sand to one of cement. The bad stone was scabbled out to a depth of from four to six inches. To provide a form to hold the concrete in place, two or more holes were drilled about four inches deep in the face of the cavity to be filled, and a plug driven in having a central $\frac{3}{8}$ -inch hole. Old broom handles sawed to 4-inch lengths were used for these plugs. Five-eighth inch iron bolts, of various lengths, with a taper thread cut on one end and an ordinary thread and nut at the other end, were screwed into these plugs. The taper part of the bolt was inserted in the plug, and when screwed home would expand the plug and prevent the bolt from being pulled out. The molds were short pieces of two inch plank driven over the bolts and held in place by the nuts. It was found necessary to wrap the screw bolt with paper where the concrete surrounded it; otherwise it would be impossible to withdraw the bolt when the cement had set.

Repairs to Lock Gates. The life of the lock gates, which were originally constructed of oak, appears to be dependent upon their exposure to atmospheric influences. In 1891 it was necessary to rebuild the guard lock gates, which remain open during low water and are fully immersed only at extreme flood stages. They were again renewed in 1905. In 1893-4 the gates of the middle lock were reconstructed, and in 1901 those of the lower lock, which are the least exposed, being protected to a greater or less extent by back water from the river except at extreme low stages. The bottom timbers to a height of six feet above the miter sills of the guard lock and the bottom timbers of the lower gates of the middle and lower locks, being immersed except when the canal is drained, were found to be in good condition. In the upper gates of the lower and middle locks the two lower tiers of timbers did not require to be rebuilt.

In making repairs to the gates and masonry of the lower lock, it was necessary to drain the lock chamber. As the lock foundation is rock, the usual pile cofferdam could not readily be employed to keep out the river water, and the canvas bulkhead invented by Mr. M. Meigs, U. S. Civil Engineer, and described in the *Transactions of the American Society of Civil Engineers*, Vol. XXXI, page 524, was used. This bulkhead (Plate XIV) consists of a timber frame of triangular cross section, having a length equal to the width of the lock entrance. It was sunk in position by being loaded with railroad iron and made water tight by covering it with a sheet of 12-ounce canvas extending several feet beyond the toe. When the lock chamber was pumped out, the flow through or under the bulkhead was insignificant. As soon as the work was completed, the railroad iron was removed from the bulkhead, which then floated to the surface and was readily removed and broken up, the timber used in its construction being available for other purposes.

Repairs to Machinery. Since the opening of the canal two of the hydraulic cylinders have been burst by frost and had to be replaced. This was due to water being left in them when the plant was laid up for the winter. By putting in special light valves on the suction side of the pumps, the hydraulic pumps are now used as air pumps and sufficient pressure obtained to drain the cylinders dry and blow most of the water out of the pipes, thus reducing the danger of freezing to a minimum.

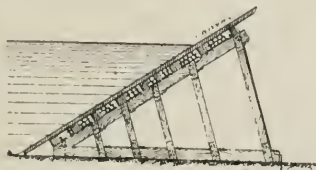
Repairs have been required to the pipes conveying the hydraulic pressure. These pipes became pitted, especially close to the brass shut-off, and drain valves in the angle between the lock wall and breast wall, apparently due to galvanic action, the iron rusting away and the brass remaining intact. Many leaks have occurred in the pipes behind the lock walls. These leaks are ordinary corrosive punctures or pits, and have been repaired by uncovering the pipe and applying a patch of gum covered canvas held in place by an iron clamp. The set of pipes crossing the canal below the guard lock were renewed in November, 1896, canvas bulkheads being employed to keep the water out while the repairs were being made.

The wire ropes used for manipulating the gates last about six years. The sheaves in the multiplying apparatus were badly worn by 1882; they were taken out and bushed with bronze, and have given no trouble since then. The gate chains of $\frac{1}{2}$ -inch iron last five or six years under water and much longer in the air. The culvert chains, which are subjected to a heavy pull, required no repairs until 1901, when lengths five or six feet had to be replaced at the lower and middle locks. At the guard lock, where the cuverts are comparatively little used, the chains are still good.

Repairs to Embankment. The high water of 1881 very nearly went over the canal embankment at several localities, due to a settlement of the material of which it is composed, and considerable work was required to bring it back to the prescribed grade. During

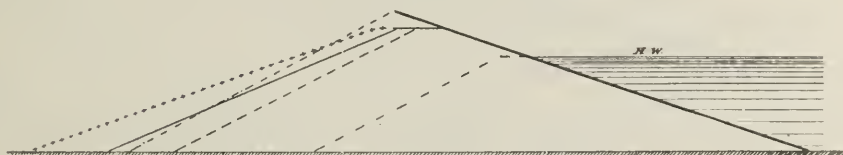
PLATE XIV.

CROSS-SECTION
OF
CANYAS and PLANK BULKHEAD



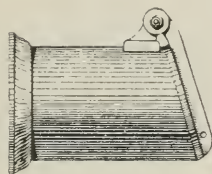
TYPICAL LEVEE SECTIONS

Scale: 0 5 10 15 20 25 30 ft

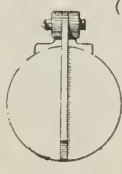


SNY LEVEE original — — — — —
SNY LEVEE enlarged — — — — —
FLINT CREEK LEVEE — — — — —
WARSAW to QUINCY LEVEE — — — — —
LOWER MISSISSIPPI LEVEES + + + + +

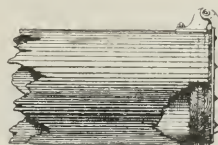
OUTFLOW VALVES.
(in Levees)



SIDE ELEVATION



FRONT

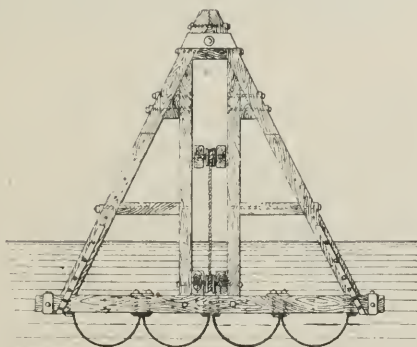


SIDE ELEVATION

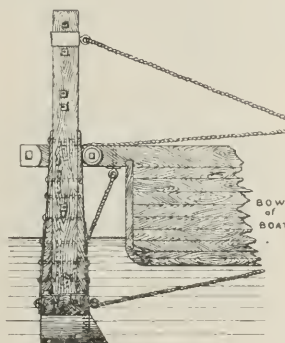


FRONT

SANDBAR SCRAPER
to operate in 1 to 10 ft of water



FRONT ELEVATION



SIDE ELEVATION

the flood of 1888 a section about 50 feet in length in the upper level sloughed and began flowing into the canal. A break was prevented by throwing a couple of barges of stone into the gap and covering the stone with earth. A few minor leaks in the embankment have also been observed from time to time, which have been repaired during the summer months when both the river and canal were low.

In 1882 several leaks were noticed under the embankment near the site of the dry dock, above the middle lock. These kept on increasing until in 1884 an attempt was made to stop them. During the winter, when the water was drawn off from the canal, the outer half of the embankment was dug away for a distance of 500 feet, and a trench cut in the alluvium that underlies the embankment. Selected earth was carefully rammed into this ditch and the embankment rebuilt. In 1892, after the dry dock had been built, sufficient seepage was observed through this foundation to fill and gorge a 6-inch drain, provided for carrying off any seepage that might occur, under the dry dock floor. A row of 3-inch sheet piling with tongue and groove was then driven through the embankment to bed rock where possible. No further trouble was experienced. A similar leak occurred in 1894 above the lower lock, which was also stopped by driving sheet piling.

Owing to the inferior quality of the stone, the slope wall lining on the canal side of the embankment has in many cases disintegrated. In 1901 the gaps thus caused were filled with rip rap rock.

Dredging. A large item in the cost of maintenance has been the periodical dredging required to remove the deposits formed in the canal. While some sediment is deposited from the river water, the principal source of trouble is material washed in from the neighboring hills during storms. The creek at Sandusky during severe storms brings into the canal sufficient sand and gravel to interrupt navigation until a channel can be dredged through the obstruction. There have been removed from the canal from 1878 to June 30, 1906, 2,181,743 cubic yards—an amount in excess of the excavation during construction.

IMPROVEMENT OF THE ROCK ISLAND RAPIDS.

The Rock Island Rapids extend from the lower end of the village of Le Claire, Iowa (Mile 348), to the Rock Island bridge, a distance of 14.26 miles. The fall between the head and foot of the rapids at low water is 20.7 feet; at the extreme high water of 1892, 15.2 feet. The bed of the river through the rapids consists of a hard surface of limestone rock worn in many places into deep furrows by the long continued action of the water and the material washed along the bottom. There are also encountered a number of large granite boulders. The rock appears as reefs or chains across the river at twelve localities, shown in Plate X. There existed through these chains, prior to the improvement of the rapids, a narrow tortuous channel, which was navigated with difficulty, not only on account of lack of

THE HISTORY OF THE

REIGN OF

CHARLES THE FIRST

BY

JOHN BURNET

OF THE UNIVERSITY OF OXFORD

IN TWO VOLUMES

LONDON

Printed by J. St. John, at the

Printers Office, in St. Dunstons Church-yard

1704

MDCCIV

Printed by J. St. John, at the

Printers Office, in St. Dunstons Church-yard

1704

MDCCIV

Printed by J. St. John, at the

Printers Office, in St. Dunstons Church-yard

1704

MDCCIV

Printed by J. St. John, at the

Printers Office, in St. Dunstons Church-yard

1704

MDCCIV

Printed by J. St. John, at the

Printers Office, in St. Dunstons Church-yard

1704

MDCCIV

Printed by J. St. John, at the

Printers Office, in St. Dunstons Church-yard

1704

MDCCIV

Printed by J. St. John, at the

Printers Office, in St. Dunstons Church-yard

1704

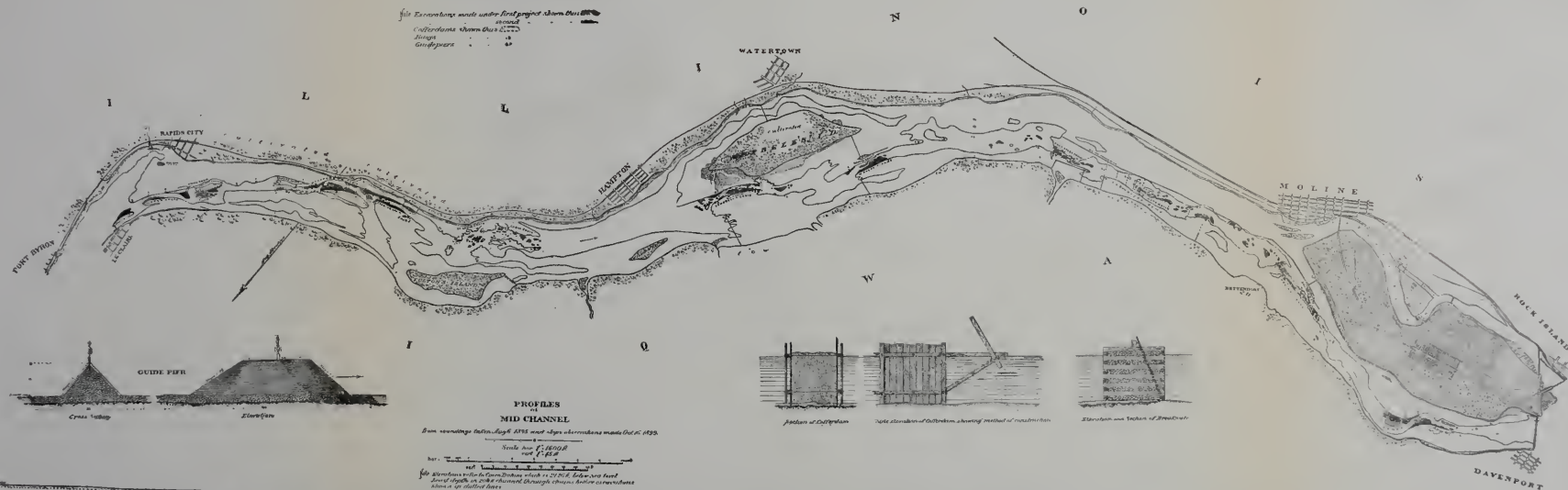
MDCCIV

Map profiles
of
ROCK ISLAND RAPIDS,
UPPER MISSISSIPPI RIVER

compiled from surveys made in 1868 & 1872

Scale of Map 1:100,000

For excavations made under first project down this river
at present shown blue
excavations shown blue
excavations shown blue
excavations shown blue

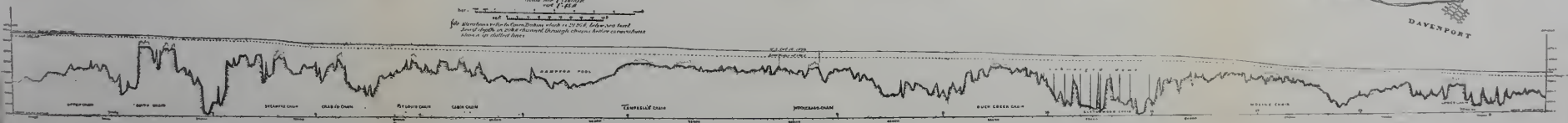
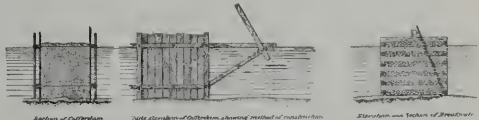


PROFILES
OF
MID CHANNEL

From soundings taken Aug. 1871 and Aug. 1872, and other observations made Oct. 1872.

Scale of 1:100,000
and 1:12,500

For elevations refer to the same section which is on the same page as the
level depths on this channel through which the river is navigable
from the first dam to the second



width and depth but also by reason of rapid cross currents and sharp turns. Between chains the channel was generally wide and navigable. The slope is not so uniformly distributed as on the Des Moines rapids, the channel consisting of a series of pools separated by chains over which the slope is steep.

In 1852, Congress made an appropriation of \$100,000 for the improvement of the Rock Island and the Des Moines rapids. Under this appropriation about \$15,000 was expended on the Rock Island rapids, resulting in the removal of about 3,400 cubic yards of rock from Sycamore and Campbell chains. Work was then suspended until 1866, when a Board of Engineers was convened for the purpose of considering and recommending a plan for the improvement of the rapids. This Board recommended that the steamboat channel be enlarged by excavating to a minimum width of 200 feet and a navigable depth of 4 feet at the time of low water, the recommendation being made in view of the economical execution of the work and the existing demands of commerce.

The Board was also of the opinion that should the ultimate interests of commerce demand a greater depth than 4 feet, the plan of an independent canal and locks without dams would then best promote those interests, the practicable result of such a plan being beyond question. The improvement that had been proposed by means of locks and dams across the river was considered inadvisable; it would form an obstruction permanent throughout the year, whereas at high and ordinary stages no hindrance to navigation existed.

It was estimated that to obtain a channel 200 feet wide and 4 feet deep at low water would require the removal of 57,451 cubic yards of rock, at a cost of \$813,601.80.

The above project was duly approved and the work was begun under it at Duck Creek Chain in September, 1867. The project was completed in 1882, at a cost of \$1,166,608.50, 87,926 cubic yards of rock having been removed.

In 1888, a Board of Engineer officers was convened to prepare and submit a project for the further improvement of Rock Island Rapids, either by widening or deepening the present channel through the rapids or by a canal around the rapids on the Illinois side of the river.

The Board submitted estimates for two methods of further improvement: A canal around the rapids on the Illinois side of the river, and widening and deepening the present channel of the river at the rapids. The estimate for a canal in the bed of the Mississippi river, 200 to 500 feet wide and having a depth at low water increasing from 6 feet at the head to about 12 feet at the foot, was \$3,704,722.67. To enlarge the river channel to 400 feet width and 4½ feet depth below water, the cost is estimated at \$1,258,866. To enlarge the river channel to 400 feet width and 6 feet in depth below low water, \$3,491,010.

The improvements recommended by this Board were:

1. Guide piers, with lights and day beacons, of sufficient strength to resist the action of ice and of sufficient number and so located that while being of no obstruction to navigation they will serve as reliable guides to pilots in making the passage at night.

2. To excavate and remove rock at various points, in order to widen and straighten the channel at crooked portions of the rapids, giving longer straight reaches, and to deepen it at some places, as at Duck Creek Chain. Such excavation will include the several small patches of rock lying on or near the channel.

3. A system of dams is proposed for slightly raising the water surface at low stages and equalizing to a certain extent the slopes above and below Hampton, especially the current through Campbells Chain, with a view of preventing the deposit of sand in the channel. The estimate of cost:

Rock excavation, 33,140 cubic yards, at \$6.....	\$198,840
Dam construction, 39,500 cubic yards, at \$1.50.....	59,250
24 piers, at \$1,500.....	36,000
Dredging	5,000
Contingencies	39,909
	\$328,999

Work was begun under this project and was practically completed in 1906, but with material modifications. The dams constructed at Campbells Chain not only scoured out the sand in the channel, but also materially increased the depth of water and diminished the slope on the three chains above. At Duck Creek Chain a similar set of dams was introduced, which rendered rock excavation unnecessary in the channel at this locality, and reduced the velocity of the current on the Winnebago Chain above and to some extent on Campbells Chain. The slope at Duck Creek Chain then became excessive and was lengthened by constructing in the pool below a series of submerged dams extending to within 6 feet of the low water surface. Prior to 1876 the work was done by contract; since that date by the employment of government plant and day labor.

The methods of rock excavation employed were:

1. By cofferdam, drilling by hand, and use of common blasting powder.

2. By chisel and dredge.

3. by drillboat, submarine blasting with dynamite, and removal of rock by dredge.

1. *By cofferdam.* The method of constructing the dams was as follows (Plate X): A breakwater was first constructed about ten feet above the proposed dam, to break the force of the current, and afford comparatively still water on the down stream side. It consisted of a series of cribs, generally about 10 feet by 10 feet, spaced about 16 feet apart in the clear, and sunk by being filled with stone.

Strong timbers were then laid from one crib to another, and a sheathing of plank was placed along the connecting timbers with one end resting on the timbers and spiked to them, and the other end resting on the bottom, the plank being inclined at an angle of about 45° with the water's surface.

Timber work for an upper corner of the dam was framed and sunk in its proper place with two pairs of lower wall timbers, one pair extending down stream and the other across, attached by means of tie rods to the frame work, the timbers of each pair being secured to each other by the middle tie rods, the outer ends being held up to the surface by a float. Small rafts were moved along on each side of the line of the cofferdam, to afford sufficient space for working. Another pair of lower wall timbers (or stringers) was then fastened by means of tie rods to the floating ends already in, and secured to one another as before. A pair of upper timbers located above the surface of the water was then attached to the fixed part of the dam. Sinking planks were spiked to the pair of lower timbers nearest to the fixed part of the dam at right angles to their length and projecting below them as much as was found by sounding necessary to keep the lower wall timbers as nearly horizontal as possible. This pair of timbers was now sunk until the ends of the sinking plank rested on the bottom. The upper timbers were raised a few inches above the surface of the water and spiked to the sinking plank, the frame thus made being weighted to keep the timbers in place. The side planks, which were chamfered to a thin edge at the lower extremities, were then driven into close contact with the bottom and spiked to the top timbers, care being taken to keep them in contact with the lower timbers. The space was then ready for filling. The puddling or filling was taken from the river bed and shore, and consisted of clay mixed with gravel, which material was always found at moderate distances from the work.

After the filling became compact the water was slowly pumped out of the cofferdam and the space inclosed was ready for the work of excavation. No special tamping or packing was employed—the material being such as to readily settle and spread into the cavities. The size of timber and thickness of plank varied according to depth of water and consequent height of dam and pressure. In deep water three rows of stringers were sometimes used as affording greater stability, and the dams were often braced from the inside at threatened points. The thickness of the filling of the upper and lower ends was about ten feet, they being generally in deeper water than the sides, which had ordinarily an inside thickness of about eight feet.

Although the dams used in the improvement of Rock Island Rapids were in general built in comparatively shallow water (from 6 to 14 feet in depth), Sycamore dam, which was the largest built, attained at some places a height of 26 feet above the bed of the river.

The quarrying was performed by the use of the ordinary hand

drill and blasting powder. The drills used varied from 1½ to 2½ inches in diameter, and the depth of holes from one to four feet. To avoid the effect of moisture in the rock and to form a water-tight magazine, the holes were sponged out and partially filled with a soft pliable clay. The drill was then forced into this clay, pressing it against the sides and making a water-tight lining. The proportion of rock excavated to powder used was 7-13 cubic yards to one pound of powder.

When the excavation was finished and the inclosure cleaned of broken rock, etc., the water was let in and the dams and cribs removed by dredge. Cofferdams were frequently damaged and sometimes broken in by passing steamers and rafts.

TABLE VI.

Table of Dimensions of Coffe-dams Constructed During Improvement of Rock Island Rapids, with Location and Quantity of Rock Excavated.

NAME OF CHAIN	Development Lin. ft.	Area Acres	Amt. of rock excavated cu. yds.
Duck Creek	1,310	2.29	5,183.80
Moline	2,645	6.03	16,958.41
Sycamore	5,171	42.91	17,376.66
Campbells	5,760	43.07	7,832.86
Smiths	2,209	4.84	5,598.87
Upper	1,710	2.26	3,697.50
Between Smiths and Sycamore No. 1.....	960	.....	805.10
Between Smiths and Sycamore No. 2.....	840	.....	817.20
Crab Island No. 1.....	1,100	.....	1,077.40
Crab Island No. 2.....	1,020	.....	1,446.90
Lower No. 1.....	1,505	2.27	2,649.60
Lower No. 2.....	1,480	2.81	2,340.50
Total excavated by coffer-dams.....	.....	.....	65,784.80

The locations of the cofferdams are shown on Plate X.

2. *By chisel and dredge.* The chisel was used for breaking rock that was found in patches or in bowlders too small in area to justify the construction of an inclosing cofferdam. The use of the chisel boat dates back to 1855, when Major J. G. Floyd, United States Agent, used on the Des Moines Rapids a stick of oak timber 12 feet long and about 12 inches square, with bars of railroad iron let into the side as ribbands to work in the uprights prepared for the purpose and set up on one end of the boat. The timber was shod with a conical shoe of wrought iron weighing about 300 pounds, and having a pyramidal point of steel. The chisels were afterwards made of wrought iron nine feet long with a steel point. The upper end worked loosely in a "head" from which the chisel was suspended, and was so arranged as to allow the chisel to glance from the rock without injury to the boat. Its weight was about 3½ tons. The steel point was detachable, so that when it became dull it could be removed and another substituted. The "head" was made of tough elm or bass wood and raw hide bolted together so as to bring the raw hide at the neck of the chisel, where there was the greatest

wear. The chisel was operated by machinery and leads similar to those of a pile driver, which were placed on a suitable flatboat. The fall was about seven feet. The boat was maneuvered by anchors, lines and windlasses, so as to cover the points desired, the chisel working from the down stream end of the boat. On the Rock Island Rapids the chisel was reported to be very efficacious where the cutting was small (18 inches or less), while on the Des Moines Rapids it was not as satisfactory.

TABLE VII.

Quantities of Rock Removed by Chisel and Dredge in the Improvement of Rock Island Rapids.

LOCALITY	Rock excavated cu. yds.	REMARKS
Duck Creek	5,917.92	Patches above and below the coffer-dam and also between Duck Creek and Moline.
Moline	2,741.78	Patches above and below coffer-dam.
Sycamore	245.18	Strip of rock on which lower end of coffer-dam rested.
Campbells	1,154.12	Patches above and below the coffer-dam.
Smiths	842.50	Patches above coffer-dam.
Upper	991.30	At head of chain.
Between Smiths and Sycamore...	1,694.71	Scattering patches of small area.
Crab Island	409.00	Patches below coffer-dam.
Saint Louis	2,795.20	Nearly all work at this chain done by chisel.
Winnebago	2,144.00	All work at this chain was done by chisel.
Lower	705.00	Strips on which the coffer-dam rested.
Total	19,640.71	

3. *By drillboat, submarine blasting and dredge.* In 1875, at St. Louis Chain, tripods were placed on the rock to be excavated, and from platforms built on the tripods holes were drilled by hand, the rock blasted, and the broken rock raised by a derrick boat. About 305 cubic yards of rock were removed by this means. While this method can be employed advantageously for small patches of rock, it has been found with the development of the steamdrill that it was more economical to mount the drill on a barge, which could be moved readily from place to place, and since 1878 the work of rock removal has been performed on the Rock Island Rapids by means of the drillboat. The latest form of drillboat employed consists of a barge 80 feet long by 18 feet wide, on one side of which are mounted two steamdrills (Plate XI). A boiler room and blacksmith shop occupy the middle of the boat, and the boat is held in position by spuds. Maneuvering lines are also attached for moving the boat out of danger during blasting operations.

The usual method of procedure is as follows: The drillboat is first spudded in position, and holes 3 inches in diameter are drilled four feet apart into the bed rock and are sunk to a depth of three feet below grade to avoid reblasting. The distance between rows of drill holes is also usually four feet. The holes are then freed from debris by flushing them out with water discharged through a hose

with a long nozzle. The charges of dynamite are then pushed to the bottom of the holes through a long tube having a slot in the side to accommodate the fuse wires, and a wad of old junk is rammed down on top of each load to tighten and hold it securely in place. The number of loaded holes on a line, ranging from 1 to 17, having been finally connected by splicing the wires to form a circuit, the drillboat is moved away to a distance of 50 to 75 feet, and the blast is then fired with a battery. The average amount of dynamite used per solid cubic yard of rock blasted is 2.29 pounds, and the average amount of solid rock blasted per day of 16 hours by one drillboat is 30.86 cubic yards. There is great variation, however, due to depth of drilling, quality of material, and the amount of sand and gravel found overlying the reefs. In deep ledge rock which breaks up so as to permit holes to be drilled eight feet apart, an output of 72 cubic yards of solid rock per day of 16 hours was obtained, with an expenditure of 1.17 pounds of dynamite per cubic yard.

The following table gives the quantity of dynamite generally used for holes of various depths and in different kinds of material:

TABLE VIII.

Depth of hole.....	3ft.	4ft.	5ft.	6ft.	7ft.	8ft.
Dynamite in hard rock, lbs.....	2½	3¼	4	4¾	5½	6¼
Dynamite in rock medium to soft, lbs....	2	2⅝	3¼	3⅞	4½	5¼

The dams on the rapids have usually been built from the rock excavated from the neighboring chains. Submerged dams are given an elevation of 6 feet below low water, the ordinary wing dams 3½ feet above low water. The longitudinal dike extending above Benhams Island was built by the Ordnance Department, U. S. Army, to increase the head on a dam in Sylvan Water that has been constructed to supply power to the Rock Island Arsenal.

Guide piers (Plate X), 16 in number, have been built to mark the channel by day and to carry lights at night. The pier foundations are of rip rap, averaging 90 feet by 55 feet, carried up to about the low water line. The piers are conical at both their upper and lower ends, with sloping sides, and average 70 feet long by 35 feet wide at the base, and 30 feet by 2 feet on top. They extend to the elevation of high water. They have a core of rip rap and are covered with facing stone laid in cement mortar having a thickness of twenty-four inches on the up-stream end and from fifteen to eighteen inches on the down-stream side. An iron socket is inserted in the top of each pier, to carry a lamp post. Spar buoys are also employed as additional aids in marking the channel. These buoys are of wood, from ten to sixteen feet in length, twelve inches in diameter at the large end, tapering to four inches diameter at the small end. On the large end of the buoy is an eyebolt which is connected by a clevis with a ½-inch chain attached to a ring bolt in the rock bottom. The

ring bolt is placed in a hole drilled in the rock and is set by a few taps of the steamdrill, the end of the bolt having been split and a wedge inserted.

In the following table is given the cost of rock excavation.

TABLE IX.

Notes on Rock Excavation.

Year	LOCALITY	Removed from (solid cu. yds.)	Cost per cubic yard	METHOD
1868	R. I. Rapids	21,253	\$10.00	
1869	"	12,671	13.00	
1870	"	1,172	13.00	
1870	"	7,833	11.50	
1872	"	5,599	10.35	Contract; coffer-dams, steam and hand-drills, powder.
1872	"	1,622	11.00	
1872	"	3,698	14.00	
1875	"	2,650	12.00	
1876	"	2,341	12.00	
1876	"	305	11.13	Hired labor; hand-drills, dredge, powder.
1879	"	682	10.78	Hired labor; steam-drill boat, dredge, dynamite.
1886	"	445	7.00	Contract; chisel and dredge.
1887	"	1,343	8.47	Contract; chisel and dredge.
1889	"	2,451	5.43	Hired labor; steam-drill boat, dredge, dynamite.
1890	"	1,398	7.20	"
1891	"	2,704	5.76	"
1892	"	1,990	4.73	"
1893	"	2,919	4.71	"
1894	"	3,852	4.70	"
1895	"	6,158	3.75	"
1895	D. M. Rapids	.....	3.05	"
1896	R. I. Rapids	5,271	4.42	"
1897	"	3,105	4.31	"
1898	R. I. Harbor	.....	4.94	"
1898	R. I. Rapids	6,320	3.37	"
1898	D. M. Rapids	5,449	2.36	"
1898	Henderson R.	693	4.14	"
1899	R. I. Rapids	5,406	3.50	"
1899	R. I. Harbor	1,441	2.47	"
1899	Rockingham	4,730	2.93	"
1900	R. I. Rapids	3,631	3.30	"
1901	"	1,000	4.34	"
1902	"	6,201	2.69	"
1903	"	6,425	3.65	"
1904	"	5,018	6.00	"
1905	"	8,670	1.00	Dredging rock blasted preceding year.

HARBORS OF REFUGE, LAKE PEPIN.

The Mississippi river steamboat is broad and of light draft, and has not been constructed to resist wave action. Storms on Lake Pepin create waves of considerable force, particularly when the wind is blowing up or down the lake, and have caused numerous accidents to river craft in their passage through it. Log and lumber rafts of large dimensions are towed through the lake, and, as the current in the lake is inappreciable, move very slowly. If exposed to a storm these rafts are broken up and scattered. The navigation interests have therefore desired some form of protection, and four piers or breakwaters have been constructed, on the leeward side of which vessels can find refuge (Plate XII).

Stockholm Breakwater. The first of these structures was built at Stockholm under acts of Congress approved August 2, 1882, and

February, 1909

July 5, 1884, appropriating \$10,000 and \$15,000, respectively, for the purpose. The breakwater has a length of 774 feet, the inner 166 feet being a rip rapped earthen embankment, and the remainder composed of 18 cribs filled with rock and gravel. The cribs are 32 feet long, and the first nine cribs from shore have a width of 20 feet, the others 26 feet. The substructure was built of pine logs and the superstructure of 12-inch square timbers with spaces of six inches between them. Two sets of longitudinal timbers divide the cribs into pockets. The outer pockets were filled with rock and the inner originally with earth and gravel. The top was covered with three inch oak plank. The height of the breakwater is twelve feet above the low water of 1864, and at its outer end has a height from the bed of the lake of twenty-four feet. Snubbing posts were provided for mooring vessels and protecting oak piles driven along the sides of the structure. This work was done under contract, and completed in September, 1885.

After passing through two winters without any material damage, the flood of the spring of 1888 broke up the ice in the lake when it was two feet thick. A violent windstorm carried a large mass of this ice against the pier, and the upper four feet of the superstructure was carried away.

As originally constructed, the sides of the cribs were vertical. In making repairs, the sides and ends of the superstructure were given a slope, as shown in the cross section (Plate XII), and covered with three inch oak plank. The angles between the crib and the bed of the lake were filled with brush and rock substituted for the earth and gravel in the center pockets. Since these repairs have been made the structure has successfully withstood the action of ice and storms.

The following is a bill of the material used, with the amounts paid the contractor:

12,930 lin. ft. logs, at 13¾ cts.....	\$1,777.88
305,956 ft. B. M. 12-inch square timber, at \$23.40 per M.	7,159.37
42,612 ft. B. M. 3-inch deck plank, at \$17.50 per M.....	745.71
32,963 ft. B. M. 2-inch pocket plank, at \$12.50 per M...	412.03
4,928 tree nails, at 5 cts.....	246.40
420 lbs. iron bolts, at \$4.15.....	17.43
2,713 lbs. spikes, at \$4.33.....	117.47
4,666.2 cubic yards rock, at \$1.....	4,666.20
3,494 cubic yards gravel, at 25 cts.....	873.50
	\$16,011.99
Repairs by United States.....	6,416.62
Surveys, superintendence, office expenses and contingencies	2,571.3
	\$25,000.00

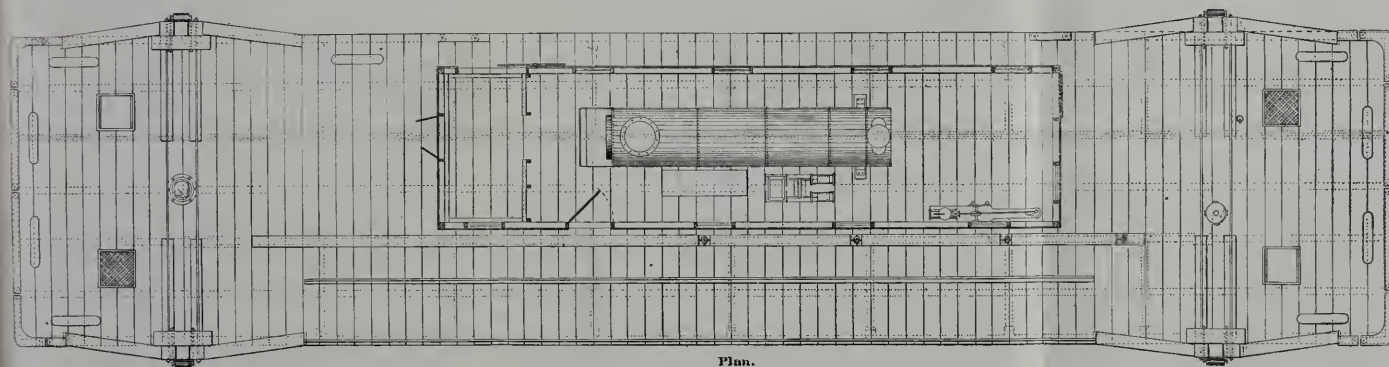
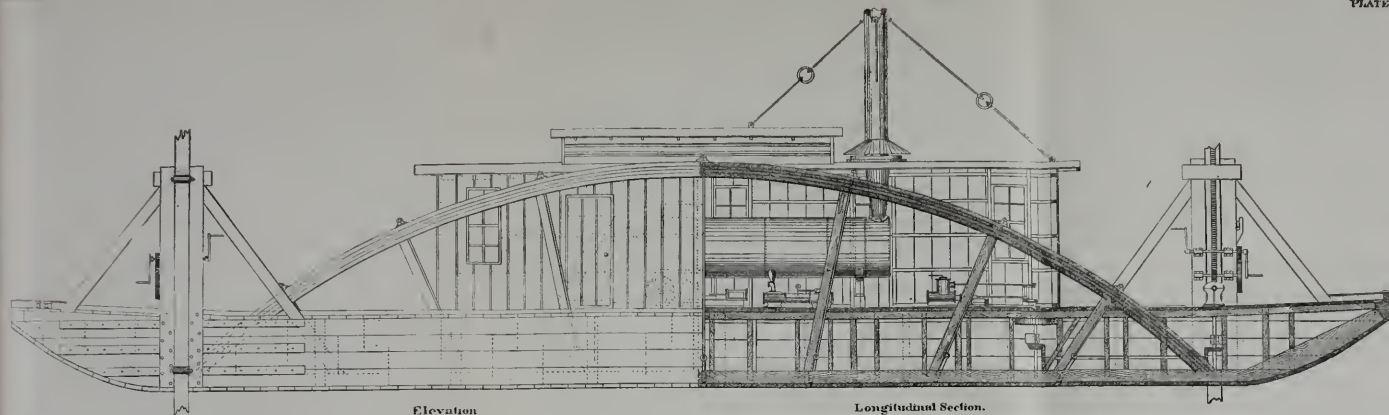
ater on
Point,
it was
oor for
oss the
ith the
71 feet,
gravel
om the
ight of
ve low
a layer
rest on
educed
num of
hose in
32 feet,
planked
1.23.

of the
: would
k from
k flush

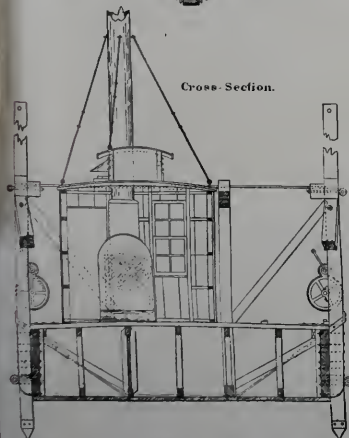
mbank-
d Lake
t Kings
ient the
was de-
am was
ats and
ong the
as built
t grad-
i of the
e. The
ve ver-
water,
with a
iminish-
re pro-
truction
ck, and
\$30,000.
irty-six

ured by

7. No. 1

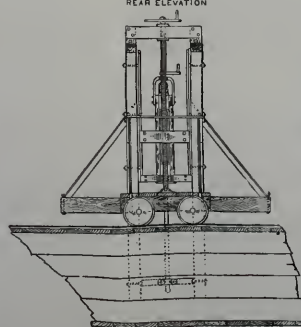


Cross-Section.

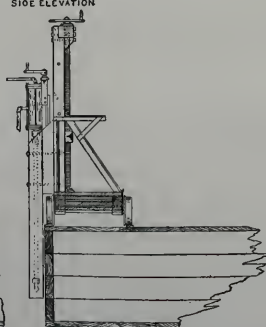


Carrige.

REAR ELEVATION



SIDE ELEVATION



PLAN, ELEVATION and SECTIONS
of
U. S. STEAM DRILL BOAT
80'x18'.

UPPER MISSISSIPPI RIVER IMPROVEMENTS.

Scale $\frac{3}{8}$ " = 1 ft.

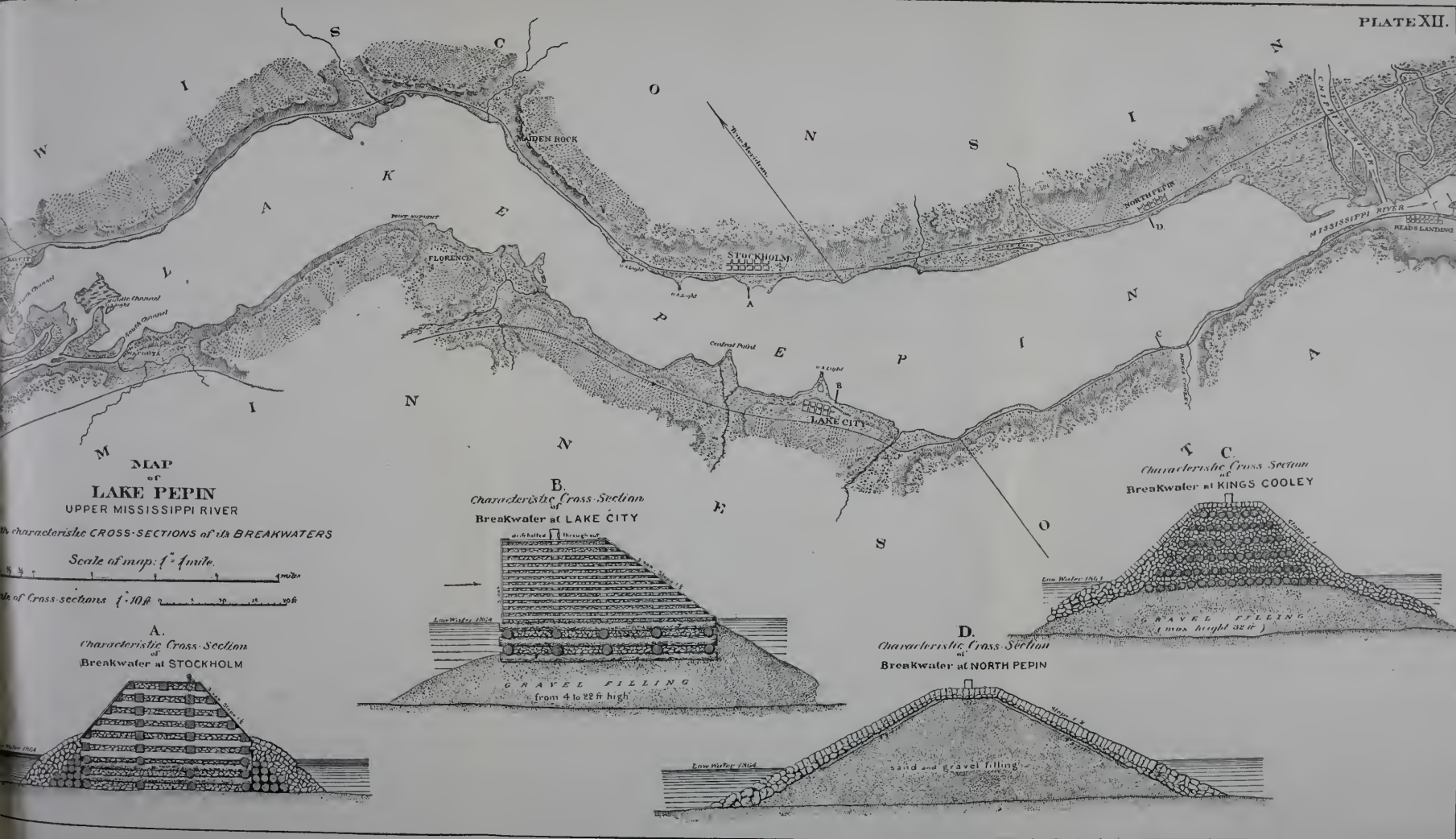
ater on
 Point,
 it was
 or for
 oss the
 ith the
 71 feet,
 gravel
 om the
 ight of
 ve low
 a layer
 rest on
 educed
 num of
 hose in
 32 feet,
 blanked
 1.23.

of the
 : would
 k from
 k flush

mbank-
 d Lake
 t Kings
 ent the
 was de-
 am was
 ats and
 ong the
 as built
 t grad-
 of the
 e. The
 ve ver-
 water,
 with a
 iminish-
 re pro-
 truction
 ck, and
 \$30,000.
 irty-six

ured by

7. No. 1



Lake City Breakwater. The natural location for a breakwater on the western side of the lake opposite Stockholm is at Central Point, north of Lake City. Upon petition of the citizens of the town, it was placed at Lake City, and forms with the point above, a harbor for the town, protected from all storms except those coming across the lake. The latter are rarely sufficiently severe to interfere with the use of the harbor. The breakwater has a length of about 871 feet, of which 512 are constructed of cribs, and the remainder is a gravel embankment. The embankment is built of gravel dredged from the bed of the lake, has a width of seventeen feet on top and a height of thirteen feet above the low water of 1864. The slopes above low water are $1\frac{1}{2}$ horizontal to 1 vertical, and are covered with a layer of rip rap rock, from $2\frac{1}{2}$ to 1 foot in thickness. The cribs rest on a gravel foundation, deposited from dump scows, which reduced the depth of the lake along the line of the pier from a maximum of 28 feet to 5 feet below low water. The cribs are similar to those in the Stockholm breakwater, except that they have a width of 32 feet, and on the harbor side the superstructure is vertical and planked with two inch oak planks. The cost of the work was \$31,985.23.

As originally constructed the plank on the sloping side of the superstructure extended some distance beyond the crib. Ice would form under this overhang and as the lake rose, tear the plank from their supports. By the simple method of cutting the plank flush with the sides of the cribs this difficulty was obviated.

Kings Coulee Breakwater. It was observed that the embankments at the shore ends of the breakwater at Stockholm and Lake City suffered less from ice than the timber structures and at Kings Coulee the experiment was tried of extending the embankment the entire length of the breakwater. A foundation of gravel was deposited to a stage five feet below low water and on this a dam was constructed of brush and rock, the brush being woven into mats and sunk in the usual manner. The length of pier measured along the top of the gravel foundation is 700 feet. For 650 feet it was built to a stage twelve feet above low water, the outer fifty feet gradually sloping to a grade four feet above datum. The width of the pier is ten feet on top and thirty-six feet at the low water line. The slopes above low water are thirteen feet horizontal to twelve vertical, and below low water the natural slope of gravel under water, about 1 on 4. The surface of the breakwater is covered with a rip rap of stone from $3\frac{1}{2}$ to 4 feet thick at low water and diminishing to 2 feet in thickness at the top. Snubbing posts were provided for mooring vessels. There were expended in its construction 109,041.8 cubic yards of gravel, 11,009.6 cubic yards of rock, and 19,356 cubic yards of brush. The cost of the work was \$30,000. The depth of the lake at the outer end of the breakwater is thirty-six feet below low water.

The pier has settled considerably, and has been slightly injured by

wave action. No appreciable damage from ice has yet been observed.

By the River and Harbor Acts of June 13, 1902, and March 3, 1905, \$25,500 was allotted for constructing a fourth breakwater at North Pepin. This breakwater has a length of about 1,000 feet, but is built in shoaler water than the other three. It is composed of a sand and gravel core, covered with rip rap rock. Thirty-six thousand two hundred and thirty-eight cubic yards of sand and gravel and 8,586 cubic yards of rip rap rock were expended in its construction.

HARBORS OF REFUGE FROM ICE.

When the ice breaks up in the spring, it frequently floats down the river in masses sufficiently large to destroy any boat with which it may come in contact, and it is necessary for boats to lie up during the winter at places where they will not be exposed to this action. The outlet of a side slough frequently affords such protection, and a number of sloughs are used as ice harbors for rafts of logs. The Des Moines Rapids canal and the portion of the Illinois and Mississippi canal around the rapids of Rock River are also extensively employed for a similar purpose. For steamboats it is desirable that the ice harbor should be in the vicinity of some large town, so that the necessary repairs for another season can be made while the boat is laid up. Appropriations have been made for ice harbors, at Dubuque, Iowa (Mile 265), at Davenport, Iowa (Mile 363), and at Quincy, Ill. (Mile 521).

The ice harbor at Dubuque has been constructed by the General Government deepening Waples Cut, a natural harbor, in front of the city, while the local authorities have filled in around it. The harbor has an area of about twelve acres and has been dredged to a depth of six feet below low water. There has been expended for the purpose \$45,000. Occasional dredging is required to keep the entrance open. At Davenport a harbor has been constructed behind Credit Island by building a dam across the upper end of the slough and dredging an area of 293,430 square feet to five feet below low water. The dam was originally given a height of eight feet above low water by the government, but afterwards raised to thirteen feet by a railroad company. There was expended on the work by the United States to June 30, 1906, \$13,046.80.

In the bay above Quincy, Ill., an area of eighty-two acres has been dredged to a depth of six feet below low water, at a cost of \$129,481.36. This harbor not only affords refuge for boats, but a large portion is occupied by log rafts stored for the use of mills in the vicinity. There is considerable deposit in the bay from streams and sewers emptying into it, which has to be removed by dredging.

Appropriations and allotments have also been made for improving the river in front of certain cities and towns along the river, and these have been frequently designated as "improving the harbor" at

the locality. In such cases the work to be done usually consists in removing a bar which has been formed in front of the steamboat landing of the town by sand moving down the river. The methods of improvement adopted have been either dredging, or contracting the width of the river by the construction of wing dams on the bank opposite the town, so as to cause the river currents to remove the obstructing bar. In the following table is given a list of such special appropriations and allotments.

TABLE X.

Appropriations and Allotments for Local Improvements, Upper Mississippi River.

LOCATION		Allotments from gen- eral appro- priations	Special appropriations	Total	Amount expended to June 30, 1906	Method of Improvement
La Crosse.....	L 144	\$ 5,000	\$ 12,000	\$ 17,000	\$ 13,821.05	Contraction and dredging.
Prairie du Chien..	L 208	30,000	.....	30,000	30,000.00	Contraction.
Guttenberg	R 229	.....	8,000	8,000	8,000.00	Contraction.
Dubuque	R 265	25,000	41,000	66,000	66,000.00	Dredging.
East Dubuque	L 265	.....	.....	.....	.....	.....
Clinton	R 327	25,000	.....	25,000	22,071.15	Contraction and dredging.
Port Byron.....	R 348	5,000	.....	5,000	5,000.00	Dredging.
Rock Island.....	L 363	10,000	12,000	22,000	22,000.00	Dredging and rock excavation.
Andalusia	L 372	.....	6,000	6,000	6,000.00	Contraction.
Muscatine	R 390	15,000	20,000	35,000	35,000.00	Dredging.
Burlington	R 442	5,000	30,000	35,000	35,000.00	Contraction and dredging.
Ft. Madison	R 463	.....	24,100	24,100	24,100.00	Contraction.
Montrose	R 472	2,000	.....	2,000	2,000.00	Dredging.
Quincy	L 521	20,000	15,000	35,000	26,505.31	Contraction and dredging.
Hannibal	R 540	15,000	45,000	60,000	59,755.67	Contraction.
Louisiana	R 568	.....	10,000	10,000	10,000.00	Contraction.
Clarksville	R 578	15,000	.....	15,000	15,000.00	Contraction.
Hamburg Bay.....	L 590	10,000	.....	10,000	10,000.00	Dredging.
Alton	L 652	.....	108,000	108,000	108,000.00	Contraction and dredging.

A lock is under construction in front of Moline to afford that city a connection with the river, but as this lock will become a portion of the enlarged project for improving the river its description is omitted.

LEVEES.

At a 6-foot stage the river begins to overflow the bottom lands; above a 12-foot stage the overflow of the alluvial valley is extensive, although there are certain sand ridges that are above any recorded stage of the river. The floods are usually of short duration, and most frequently occur in June or July.

While there are many tracts of land that have been partially protected from overflow by their owners, there are but three levee districts along the Upper Mississippi river that have received appropriations from the General Government, i. e., the levee from Iowa river to Flint Creek, Warsaw to Quincy Levee, and Sny Levee.

Levee from Iowa River to Flint Creek (Miles 411-440). The River and Harbor Act of August 17, 1894, provided for a survey on the west side of the Mississippi river.

"* * * commencing at the mouth of Flint Creek, in Des Moines County, State of Iowa, and running along the west bank of the river to the mouth of the Iowa river, * * * with a view to improving the navigation by preventing the water from overflowing the natural and artificial banks along those parts of the river and deepening the channel."

This was interpreted to mean that Congress desired an estimate of the cost of a levee that would prevent overflow of the west bank of the river between the points mentioned. A survey was made in accordance therewith and an estimate of cost of \$305,000 submitted. By the act of March 2, 1895, Congress appropriated \$85,000 to begin the work, and to March 3, 1899, had allotted \$300,000 for its construction.

The levee has a length of $35\frac{1}{4}$ miles and protects from overflow about 44,700 acres. The levee section originally adopted had a width of crown of four feet, land slope 1 on 2, and river slope of 1 on 3. The grade of crown is three feet above the flood of 1888. When the writer was assigned to the charge of the district, in 1898, he increased the section by giving a width of six feet to the crown and a land slope of 1 on $2\frac{1}{2}$. The levee section adopted on the Lower Mississippi river, which has a crown from eight to ten feet in width and a land slope of 1 on 3, it was believed, could be safely reduced, as the floods on the upper river are of shorter duration, and as great an increase in flood height from levee construction is not to be apprehended.

The method of levee construction was as follows: The ground occupied by the levee was first cleared of trees, stumps, and all other perishable matter, all trees and stumps being grubbed out by the roots to three feet beyond the slope stakes. The surface of the ground was then thoroughly broken by spade or plow to form a bond with the earth deposited. The specifications required that such top soil as in the opinion of the engineer in charge was unfit for the foundation should be removed and deposited to form a banquettes on the land side of the levee, together with such top soil from the borrow pits; but the ground along the levee was of such a character that little material was rejected. A muck ditch was then cut three feet from the center line of the levee on the river side. Its dimensions usually were four feet by four feet. The object of the muck ditch is to explore the foundations and improve the bond between the foundation and the embankment. The muck ditch was then filled with approved material and thoroughly tamped, usually by teams passing over it. The embankment was then deposited in layers not exceeding two feet in thickness when moved by scrapers (the usual method). If constructed by wheelbarrows, the specifications prescribed that the layers should not exceed one foot in thickness and should be carefully tamped by employing one rammer to two wheelbarrows. The embankment was carried to one-tenth its height above the established grade to allow for shrinkage. The material

was generally obtained from borrow pits on the river side, at a distance not less than twenty feet from the base of the levee, but in a few cases it was necessary to obtain a small portion of the material on the land side, and in such cases the limit of the borrow pits was sixty feet from the toe of the land slope.

As the levee line extends to the bluffs at the lower end of the district, to protect against back water, it has been necessary to make provision for the ordinary drainage of the land during rain storms. This has been accomplished by running pipes with outflow valves through the embankment at the various sloughs and streams it crosses, so that when the river is low, water can flow outward, but if high the closed valve would prevent an inflow. Ordinary 36-inch cast iron water mains were employed for the purpose, having a thickness of $\frac{7}{8}$ of an inch, the standard bell and spigot joint, and an average weight of 4,200 pounds, for lengths to lay twelve feet. The pipes were laid without calking the joints.

Three kinds of outflow valves have been tried. The first was an iron valve (Plate XIV), about five feet long, which cost \$86.43. The second was also an iron valve, about one-half as long as the first, and with a flange on the lip, and planed faces, which made a tighter and better joint. This valve cost \$70. But with both these valves it was found that a head of water of about one foot was necessary to open the valve, unless a counter balance was provided. This counter balance consisted of an old rail attached to the valve by a wire rope and so pivoted as to take up the surplus weight. A wooden shutter (Plate XIV), costing about \$11 was, however, found to be much cheaper than either of the iron valves above mentioned. The objection to the wooden valves is their tendency to warp in such a manner as to allow considerable leakage. They are also more easily broken than the iron valves.

At the outlet of these drainage pipes were built rubble retaining walls to prevent earth from sliding in and filling the pipes; and an apron was also constructed to receive the outflow and prevent erosion. On the land side of the levee the entrances to the drainage pipes were protected by a rip-rap of rock.

When the levee was exposed to wave wash, the slope was revetted with a layer of rip-rap about nine inches thick, extending from the toe of the slope to an elevation about one foot below the high water of 1888. The length thus revetted was 14,770 feet. The rest of the levee slope was sown with grass seed, so as to form a sod to protect the embankment from rain wash.

It was occasionally necessary to construct the levee close to the bank of the river or a slough where it was liable to be injured by the caving of the banks. In such cases the bank was revetted. These shore protections were constructed in the manner customary on the Upper Mississippi river.

The revetment along the Mississippi river at Crutchfield Prairie, above Oquawka (Mile 429), 8,000 feet in length, was considered a

part of the general river improvement and paid for from the General Appropriation, while the 6,876 feet of shore protection on the Iowa river and Huron Slough was paid for from the allotment for levee construction.

COST OF THE WORK TO JUNE 30, 1906.

Surveys	\$ 5,794.72
Right of way.....	444.75
Drainage pipe valves, etc.....	10,618.23
Revetment of levee banks, 14,770 feet.....	5,457.64
Shore protection, 6,876 linear feet.....	9,645.97
Earthwork, 1,856,351.4 cubic yards.....	233,963.97
Superintendence and inspection.....	29,555.05
Repair and maintenance.....	4,076.15
Total	\$299,556.48

The right of way was generally granted by local authorities without cost to the United States.

This levee successfully withstood the flood of June, 1903, which at the upper end of the levee district was the highest on record.

Warsaw to Quincy Levee (Miles 489-520). This levee was built by local levee boards from 1881 to 1888, with a cross section having a width of crown of five feet, a land slope of 1 on 2 and a river slope of 1 on 3. It has a length of about 40 miles and protects from overflow about 52,000 acres of land. There has been expended by the United States in raising and strengthening this levee to June 30, 1906, \$101,428.03. Crevasses occurred during the floods of 1881, 1888, 1892, 1897 and 1903.

Sny Levee (Miles 533-584). This levee extends from the bluffs below Quincy, Ill., to Hamburg Bay, and protects an area of about 124,500 acres. It was originally constructed with a cross section similar to the Warsaw to Quincy Levee, but has since been enlarged to a triangular section with a land slope of 1 on 2 and a river slope of 1 on 3, the apex being five feet above the high water of 1892. There has been expended by the United States on this levee \$106,728.99, \$50,000 for levee enlargement and the remainder for the protection of the levee from caving banks. Crevasses occurred during the floods of 1876, 1880, 1881, 1888 and 1903.

REMOVAL OF SNAGS AND OTHER OBSTRUCTIONS.

By the Act approved March 2, 1867, an appropriation of \$96,000 was made for building and operating two dredge and snag boats. With this appropriation two steamboats were purchased and equipped with shears, for pulling snags, and with Long's Scraper, for lowering the crests of sand bars. Long's Scraper (Plate XIV), an invention of the late Colonel Stephen H. Long, Corps of Engineers, appears to have been the most successful of the various devices that have been suggested to temporarily improve navigation during low water. It consisted of a triangular frame of oak timber, with buckets

or cutters of boiler iron bolted to the lower side. It was attached by bolts to the sides of the boat, and was raised or lowered by two ropes, one of which was fastened to the bow of the boat and passed under a pulley near the lower end of the frame, thence over a pulley on a bow sprit projecting from the boat, and thence to the forward steam capstan; the other rope was attached to the apex of the triangular frame and passed over a pulley connected to the shear boom and thence to an aft capstan. The method of operating the scraper was to move the boat to the head of the shoal to be dredged, and to lower the scraper on the bar; the wheels of the steamer were then backed so as to drag the scraper over the bar, the boat floating with its stern down stream. After having been dragged across the bar, the scraper was raised out of the water and the steamer returned to the initial point. The operation was then repeated until the desired depth was obtained. The buckets cut up and loosened the material on the bar and then conveyed it down stream and deposited it in deep water, being assisted in the movement of the material by the river currents.

These scrapers were quite extensively employed until appropriations were made for the permanent improvement of the river, when dredges were substituted for them.

In the report of the Chief of Engineers for 1880, page 1485, it is stated:—

“The results not being commensurate with the amount of time and labor required, comparatively little of this kind of work has been done of late years. So many bars scattered over the entire 700 miles of river becoming obstructions simultaneously at each recurring low-water, it was found a hopeless task to keep them all open with one boat, and unless a channel is cut through *all* and *maintained* the work cannot be considered successful. And again, the results have no permanency, the work of the scraper being generally obliterated at each rise of the river, however slight, and in many cases a single night will destroy the work of the previous day. In increasing the depth on a bar for the time being the scraper is generally very effective and is now often used in special cases where it is thought that a channel once cut will maintain itself.”

In such cases, however, it was found that the ordinary dipper dredge was more economical, and the work of the boat has been confined to snagging operations and the removal of wrecks and bowlders.

Trees and stumps on caving banks fall or slide into the river and work out into the deepest channel water. These form what are called *snags*, and whether entirely under water or partly exposed are dangerous obstructions to passing boats and rafts. Many snags are brought into the main river from the tributaries in times of flood. Many lodge on bars or shoal places and lie there, perhaps for years, imbedded in sand, until changes in channel bring them in the way of boats. During the season of navigation the river is constantly

patrolled. As the banks of the Upper Mississippi are comparatively low and generally sloping it is an easy matter to dispose of snags by hauling them out on the bank with the aid of tackle and shears, so that the expensive steam saws and other machinery used on snagboats on the Lower Mississippi, where the banks are high and steep, are not needed. A side-wheel boat is preferable for ease of handling, and the cabin is placed aft farther than usual on commercial boats, to afford more space on the bow for the men and snagging apparatus. A strong pair of shears with large blocks extending over the bow for raising snags is essential, together with powerful steam capstans.

One of the most important features of the snagboat work and one that has been most beneficial in diminishing the number of snags, is the pulling back and uprooting of large trees near the edge of the bank.

Other duties to which the boat has been assigned are: The placing of buoys, channel marks, mooring posts and ring-bolts; making surveys, assisting steamboats in distress, building and repairing dams and shore protections, and removing rocks, wrecks, and cribs. In the removal of rocks, wrecks and cribs the dipper dredge has been found to be the best instrument, and is now more commonly used. Since the abandonment of the scraper, dipper and suction dredges have been used under this appropriation in cutting temporary channels by removing sand obstructions. A large amount of rock excavation has also been performed by use of steam-drill boats, dynamite, and dipper dredge. For work above enumerated there is an annual appropriation of \$25,000.

DISCUSSION.

President Loweth: The speaker has frequently traveled, by rail, along the upper portion of the Mississippi River and is somewhat familiar with the works described in the paper just read. He has many times been impressed with the durability and efficiency of the comparatively simple and inexpensive structures by which the river has been improved, and made a serviceable highway for commerce. Great credit is due the engineers who have worked to bring about the results described. The engineer who builds a sightly structure has the satisfaction of seeing it grow to a successful completion, and finally become a monument, so to speak, to his skill of which the world may take note. But the river and harbor engineer's work is often below the water's surface, and he must be content to build a work which remains unseen, and however successful his labor may be in accomplishing the purpose sought, it is likely to be noticed only by the few who are directly interested in the use and maintenance of the channel he has made. Greater credit is perhaps due on this account to those engineers who labor under such a handicap.

Major Judson of Milwaukee and Major Rees of this city, both of the Engineer Corps of the United States Army, are present and are invited to take part in the discussion of this paper. Major Judson has recently served on a Board which investigated the effects of the reservoirs at the headwaters of the Mississippi River and the desirability of longer maintaining them. If the speaker's memory is correct, this Board found the reservoirs beneficial to the navigability of the Upper Mississippi River, as well as a benefit in other ways.

Major W. V. Judson (U. S. Engineer): There is one point—to-wit, the commercial side of the matter—that Col. Townsend did not take up. He did not discuss the value to navigation, of the channel that has been obtained. I am not specially competent to speak on this question, but so far as my general information goes it appears that commerce has been declining on the Mississippi River, regardless of these improvements, and regardless of the fact that the river is a foot and a half to two feet deeper than it was formerly; that is to say, nearly twice as deep as it was in its original state. We are often confronted by such facts in our American river improvements. I have an explanation of this situation in mind, which I believe is more or less correct. We all know that most of the commercial cities abroad were built before the days of railroads. Naturally these cities were located on lines of water communication, and conformed in many ways to the necessities of water transportation. Large amounts of money were spent in improving the streams before railroad building came along. Abroad the continent is politically cut up into small portions, and railway trunk lines are, as a rule, short. Economies in railroad transportation have not been introduced abroad to the extent that they have been in this country. On the other hand many of our cities have been built or have developed since railroad construction began, and have conformed in their development to the necessities and conveniences of rail transportation. It is to be expected therefore that we should find much more traffic on shallow interior waterways in Europe than in America.

With regard to the great public discussion we are having now with reference to inland waterways, I must confess it seems to me that many of the great projects advocated are, to say the least, of an experimental character, without sufficient promise of satisfactory commercial results. I am not prejudiced against waterways, and I know there is, from an engineering standpoint, most interesting work to be done in the improvement of rivers.

Great systems of internal waterways were projected some fifty years ago, but in many cases, after large expenditures, it was shown that these waterways would not be profitable and the schemes were abandoned to a great extent, which I think was wise. Yet there seems to be danger that this same lesson will have to be learned over again.

Your President referred to work I have been doing in connection

with the reservoirs at the head waters of the Mississippi River. We have there perhaps the greatest artificial reservoir system in the world. There are five great reservoirs that hold, all together, about 93,000,000,000 cubic feet of water. It might be interesting to describe the conflict that arose between the interests that were being served by these reservoirs, which led to the assembling of the "Board of Engineers" of which I was a member. Each interest claimed that it was suffering, as a result of the system, and the claims were all more or less absurd, of course. Some of the mills claimed that they got less water occasionally than they had before the system was established; navigation interests contended that they received but little benefit, and did not especially care for the maintenance of the system. Riparians about the reservoirs, wished them abandoned, so that they might cultivate land for which they had received flowage damages. Riparians below the reservoirs contended that floods were increased, or at any rate not diminished. None of the different interest ran parallel.

Suppose reservoirs are operated exclusively to prevent floods. Then it is desirable to keep the sluices open and the reservoirs empty at all times except when floods are threatened. Only at such times would water be accumulated and it would be released as soon as practicable to make room for succeeding floods. If reservoirs be operated for the exclusive benefit of water-power interests, then the gates are kept closed and water is accumulated except during very low stages when water is released to increase the low water discharge. These releases would occur, on northern streams, nearly all winter and during the low water period of the late summer. If reservoirs were operated to promote the navigability of a stream below, then releases would only occur during low water of the open season of navigation.

Notwithstanding these conflicts of interest, it is indisputable that reservoirs can be manipulated so as to return some measure of good to every interest, except that centering around the reservoirs themselves. The distribution of benefits, however, must always give rise to controversy.

The good that can be done to the navigation interest, and to flood sufferers as well, is relatively so small that probably in most cases it would be most in accordance with public policy to sacrifice nothing in the operation of the reservoirs to these interests, but to operate the reservoirs exclusively to benefit water-powers. Of course this suggests that in most cases reservoirs should be built by associations of water-power owners.

President Loweth: Has Col. Townsend any data showing the commerce on the Mississippi River in recent years, as compared with that of former years?

Col. Townsend: There is published annually, by the Chief of Engineers, reports showing the amount of commerce which moves on the river. The annual reports of the last two years have shown an increase in commerce, but I fear it has been due more to the

inaccuracies of preceding reports than to an absolute increase. I think more care has been used in recent years in getting up data than formerly. The greatest proportion of the commerce on the Mississippi River has always been involved in lumber, and as the lumber has been cleared away, the commerce has probably decreased.

Mr. Isham Randolph (M. W. S. E.): Is there anything to show the effect of the improvement of the upper Mississippi River on freight rates?

Col. Townsend: The published first class rates from Quincy to St. Louis, a distance by rail of 140 miles, is the same as that from St. Louis to a point 36 miles south, or from Chicago to a point 51 miles west. Between Burlington and St. Louis, 221 miles by rail, is the same rate as from St. Louis 61 miles south, or from Chicago 110 miles west. First class freight does not, however, usually seek a water route, and if the Burlington shipper happens to be a manufacturer who handles plow shares or stove castings in car load lots, he will be as favorably located, as if he resided in a town 32 miles south of St. Louis, and will have the same freight rates as the town 56 miles west of Chicago has to that city. It is evident that the Mississippi River has materially affected freight rates to St. Louis, but what is still more surprising is its influence on Chicago rates. You will find beyond the influence of Lake Michigan in Wisconsin and Illinois the lines limiting the 30c and 40c rates to Chicago preserve approximately a uniform distance from that city except in the direction of the Illinois and Lake Michigan Canal. These generally correspond to the maximum rates allowed for railroads of Class A, by the Railway and Warehouse Commissioners of the state of Illinois; but with the 50c contour there is a marked change. The maximum rates fixed by the commissioners have been abandoned and the line has become convex towards Chicago instead of concave, with cusps on the Mississippi River—one at Winona and the other near St. Louis. The trade of the towns on the Mississippi River is considered by the railways entering Chicago to be worth striving after.

The St. Louis railroads have been cutting rates to meet river competition, and the Chicago roads have to follow their example or the commerce of the river towns will go to St. Louis. The "long and short haul" regulations of the Interstate Commerce Commission, compels the establishment of as low rates to intermediate points, and the Mississippi River has produced a marked effect on Chicago freight rates through the northwestern portion of the state of Wisconsin and in southern Illinois.

President Loweth: Referring again to the question of the extent of commerce on the Mississippi River in the last two years as compared with previous years, does the increase stated refer to tonnage or to the number of crafts?

Major Judson: The report was made up, figuring the total tonnage on the river, in ton miles. There has been an increase in small, local packet lines, and a number of short lines are doing a

fair business; for instance, from Quincy to Davenport, etc. The through packet line from St. Paul to St. Louis which is in existence, carries some freight but the service is principally for carrying passengers.

President Loweth: Is there not quite a little local traffic in coal and stone, from town to town?

Major Judson: There is comparatively little coal carried on the Mississippi River. It has been observed that the commerce on the river now, is principally confined to movements over short distances. But the larger business from manufacturing centers, the carrying of coal and commodities of that kind, together with passenger business, has dwindled to a large extent.

Maj. T. H. Rees (M. W. S. E.): I think it is quite likely true that the falling off in commerce on the Mississippi River has been due to the cutting away of the forests, and the lumber business having consequently decreased.

Mr. Warder: In the matter of these ice harbors,—would there not be natural situations which might not be at a town site?

Col. Townsend: At Lake City we found it advisable to place them at the town, for there was such strong political pressure brought to bear that it could hardly be resisted. The proper place would have been at the end of the point instead of at the town. It is frequently the case that the political pressure brought to bear is so strong that it cannot be resisted. At Lake City the town wanted the harbor as a local improvement, but the proper place would have been at the end of the point instead of at the town.

Mr. Randolph: It is rather discouraging to those of us who are interested in waterways to have cold water thrown on the waterway project. I remember when Major Marshall was here some years ago, and I was appointed Chief Engineer of the Sanitary District, that he made a statement to the effect that he did not believe at all in the project, but said, "I will help you all I can" in the matter. He also said, "As to this work in connection with the improvement of the Mississippi River, the Government could better afford to burn the boats on the river and pay the people who own them to go out of business." His views on that subject used to amuse me very much. He said, too, "I am going to try all the experiments I please on the Hennepin canal, because if I fail no harm will be done, as no boats will ever go through it." When I was in Washington, Col. Craighie asked me my opinion of Major Marshall, which I gave him. He replied, "We look upon him as one of the ablest men in the Corps, but we have to edit his reports."

In talking with a gentleman recently, he said, "What is the good of these waterways? There are waterways all over the country which have been abandoned. What is the good of them?" The trouble is, they are too small to do business with. A locomotive that was in use twenty-five years ago will not handle the business of today, and the waterways are now too small for the times. They should be brought up to the business of today.

Mr. Warder: What type of snag boat did you use?

Col. Townsend: The boat used was of the type where the cabin set further back than usual, so as to give more room on the main deck, forward. We did not need those large snag boats which they use on the lower part of the river. There, an elaborate system is needed for the reason that the banks are high. In our work we found that a simple steam boat with the cabin set back was very satisfactory; we used heavy shears in front, then put a little dynamite down and blew the snags out; the snags were either hauled up on deck or were dragged to shore, where they were dried out and burned.

Maj. Judson: I spoke so pessimistically about some of the work we have been doing that I do want to say that there have been wonderful returns from much of it, especially from harbor work. I might mention as an instance the harbor at Galveston, Texas. This cost between seven and eight million dollars and it was practically completed in 1896. The result of that improvement has been that large vessels come into the docks, get their cotton, wheat, cotton-seed products or ore and leave with great despatch, where formerly they anchored out beyond the bar and it took several weeks to load them. Beyond a doubt the improvement of the harbor at Galveston alone returns in wide-spread benefits annually, a fair interest on all the money the United States has expended for river and harbor improvements all over the country from the beginning until now.

President Loweth: The development of the electric railway appears to be a factor to be considered in the present-day discussion of the value of waterways. Much is said of the need of the development of the waterways throughout the country and the public is advised of the large use made of the many waterways in Europe, and the conclusion is drawn that they would be equally valuable here. Is not the fact overlooked that electric railways are being rapidly extended? paralleling and connecting our inland cities much more thoroughly than would be possible with waterways; and these electric railways serve the communities much more efficiently and conveniently, and much more promptly than any waterways could. Small waterways in Europe are doubtless used more than they would be in this country, where the demands of modern business methods would be impatient of the slow moving boats. Having the waterways, Europe will doubtless continue to use them, but in this country where waterways, except in the case of the few large rivers, are yet to be developed, it is doubtful if they would keep pace with the rapidly extending systems of electric railways, which in most cases will provide traffic routes offering many advantages over the smaller waterways, and even over large waterways except for traffic moving long distances.

Mr. D. W. Roper (M. W. S. E.): In reading the paper which Col. Townsend has presented, I noted that in the earlier days
February, 1909

the people were satisfied with a depth of three feet and that now they want six feet. In one case that came under my observation the location of the channel was changed quite radically, as the depth of the water was increased from three feet to four-and-one-half or some other figure. The location was in the lower part of the territory in discussion, and when the three feet satisfied the people the river was diverted into the narrow chute between the Illinois shore and an island. But this chute having a rock bottom three feet below the low water level, it did not suffice when they wanted a greater depth, and so they diverted the channel to the other side of the island. When the portion of the river channel between Lamont, Illinois, and St. Louis is increased to fourteen feet, to what extent will such abandonment of completed work be necessitated by the increase in the depth?

Maj. Judson: The project as laid down by the Board of Engineers, proposes to abandon the river entirely and to build a canal from Grafton to Alton, and then from Alton to St. Louis, where the slope is excessive. They propose to abandon the river entirely and build a lateral canal.

Maj. Rees: I am sorry that I cannot add anything to what has been said tonight, but I have had very little experience on rivers anything like the Upper Mississippi. I have had some experience on some of the southern rivers, but the work was of such a different character, and mainly in connection with snagging operations, that it would not be particularly interesting to describe it this evening.

Mr. J. B. Berry: It occurred to me, when Major Judson was making his remarks, that the drop in rates is probably due to the overcrowded condition of our large cities. Anyone who is familiar with large ports, like New York, will realize how difficult it is to get such commodities as corn and cotton through those ports, hence increasing the cost per ton very materially. At Galveston there is a good harbor. I think the Mississippi River is going to be the probable dividing line of business that will come to Chicago and that which will go to the South, and the improvements in the river will make the cost per ton for handling freight from the cars to the boat much less than in our large and crowded cities. We know that in Chicago it sometimes takes twenty-four hours to get a boat from the mouth of the river to its loading place. This is entirely relieved by opening these southern ports. Galveston has grown from a million and a half bales of cotton in 1890 to about three million bales. As Oklahoma develops, those southern ports will develop very rapidly, not only in cotton but corn and wheat, so that the improvement of those harbors and the lessening of the cost is due to the overcrowded conditions of our larger cities.

Col. H. M. Chittenden (U. S. Engineers, by letter): In the Engineer district just north of that which Col. Townsend has described, very extensive works have been carried out in the interest of navigation on the Mississippi, the chief benefits of which are expected to

innure to that portion of the river which is in the lower district. This is the reservoir system of the Upper Mississippi the greatest in the world, and with exception of the similar system in Prussia, the only one which has been created for the specific purpose of improving navigation on large natural water courses. The Mississippi system consists of five reservoirs with an aggregate capacity of 93 billion cubic feet of water. As this is nearly twice the mean annual yield of the water shed, the system operates to equalize not only the annual variation of flow but also the flow from year to year and when its functions become more thoroughly understood, through increased practice in operation and longer records of rainfall and runoff, the handling of the system will be brought to a still more comprehensive basis.

There has been some doubt in the past as to the value of this public work, and in 1905 a "Board of Engineers," appointed to investigate the system, made a careful study of this question to determine the actual results in increased depth of water at Saint Paul, under the method of reservoir control then in force. As this method differed somewhat from that in force at previous dates, and as the operation of the system was interrupted for some years during reconstruction of the dams, the figures given in the table below are the results of the computation. The following extract from the Board's report gives their conclusion as to the influence of the reservoirs on the navigable depth of the river.

This report gives exhaustive data concerning the reservoir system. It is printed in the Annual Report, Chief of Engineers for 1906, pp. 1443-1474 and published also separately in pamphlet form with district officer's annual report.

While the scope of Col. Townsend's paper does not extend to this subject, being restricted to a description of works in the lower district, it would doubtless be of interest to members of the Society to know his views as to the actual benefits to navigation in that district resulting from the operation of the reservoirs.

"COMPUTED EFFECT OF RESERVOIRS ON GAGE HEIGHTS AT ST. PAUL UNDER THE SYSTEM OF MANAGEMENT NOW IN FORCE.

Year	Maximum increase in gage height Inches	Mean increase in gage height Inches	Year	Maximum increase in gage height Inches	Mean increase in gage height Inches
1885	19	12	1895	17	5
1886	32	20	1896	29	20
1887	26	15	1897	7	3
1888	20	14	1898	28	16
1889	27	17	1899	10	5
1890	20	12	1900	40	20
1891	16	3	1901	37	23
1892	22	13	1902	34	20
1893	19	10	1903	5	2
1894	21	6	1904	14	6

From this table it will be seen that the highest maximum increase in low-water depth in any one year would have been 40 inches, the lowest maximum 5 inches, and the mean of the maxima 22 inches. The mean increase ranges from 2 inches in 1903 to 23 inches in 1901, and the mean for the whole period is 14 inches. This corresponds very closely to the estimate of the Board of 1887, quoted elsewhere in this report.

There may be a difference of opinion as to which should be the true measure of benefit—the mean increase of gage height for the twenty years or the mean maximum increase during this period. The Board favors the latter figure because it is precisely at the time of the lowest water that the help to the boats of an increase of depth is most important.

There is also some question as to whether the reservoirs should be credited with the full increase of gage height as a measure of the benefit to the channel. It is generally considered that bars cut away more rapidly as the water surface approaches them, and that by holding the surface up this cutting is retarded somewhat and may not obtain the full depth that it would if the river had been allowed to fall. The Board has not the data by which to determine the application of this theory to the present case; but it believes that the effect is too indefinite to be deducted from the general results arrived at above.

Another question upon which there is some difference of opinion relates to the distance to which the influence of reservoir water extends below St. Paul. It is generally considered that Lake Pepin is the limit. The Board is unable to discover an adequate basis for this belief. The effect upon gage heights of introducing a fixed supply of water into a stream at any point diminishes, of course, with the progress downstream. There is some loss due to increased evaporation, etc., but the main cause of diminishing increase is due to the gradual expansion in the size of the stream, which requires a constantly increasing volume of water to produce a given increase in gage height. The extent of this influence depends somewhat also upon the stage of water in the river, increasing as the stage decreases. It appears that there are times when the reservoir flow into and from Lake Pepin is at least equal to the natural flow. It is frequently urged in this connection that when the reservoir water comes, it takes so long to fill up Lake Pepin that it is all lost in storage. No such result can follow under the present method of handling the reservoirs. No attempt is made to raise the surface of the river at Lake Pepin, but simply to keep them from falling. The storage is already there. Now, it would seem to be a necessary result that if the flow at the outlet of Lake Pepin is maintained so that at times it is actually double what it would be normally, the gage reading must be affected to an appreciable extent. The truth is, there is no way to determine this effect. It comes very gradually, not in actual raising of the water surface, but only in preventing to some extent its subsidence, or keeping it from falling as fast as it otherwise would, and it thus eludes ordinary observation completely."

THE WORK OF THE JOINT ENGINEERING STAFF OF THE WISCONSIN TAX AND RAILROAD COMMISSIONS

WM. D. PENCE,* M.W.S.E., M. AM. SOC. C. E.

Read December 16, 1908.

HISTORICAL.

The engineering staff which jointly serves the Wisconsin Tax Commission and the Railroad Commission of Wisconsin was organized in June, 1903, under authority of the law providing for the assessment of the steam railroad properties of the state on an ad valorem basis. The size of this staff ranged from a maximum of about 25 engineers and inspectors at the busiest portion of the first year's work, down to the minimum of two persons assisting the chief engineer after the completion of the initial valuation report. Upon this latter basis it was found to be practicable to carry forward the annual revaluations of the steam road properties. In February, 1906, the first incumbent in the position of engineer for the Tax Commission resigned, and his successor was appointed (July 1, 1906,) to render joint service for the Tax Commission and the then recently created Railroad Commission of Wisconsin.

The 1905 law prescribing the ad valorem basis of assessment for street railroad properties provided for the valuation work to begin on the initial inventory date of June 30, 1907, but the work was actually undertaken some six months earlier than that date because of a complaint lodged with the Railroad Commission respecting street car fares in the city of Milwaukee. To meet this emergency the staff was reorganized and greatly extended in January, 1907, and since that date a staff of from 20 to 30 members has been required continuously to meet the joint demands of the two commissions. Immediately upon the completion of the Milwaukee valuations in July, 1907, the field work for the valuation of the physical property of the remaining street railway and associated lighting companies of the state was undertaken, and before the completion of that work active service under the newly enacted public utilities law was inaugurated. Numerous inspection duties have also arisen in connection with several other laws recently enacted or amended.

Following is a brief outline of the several laws under which authorization or necessity for the use of a technical staff serving the two commissions has arisen:

I. THE TAX COMMISSION LAW. (Wis. laws, 1905, chap. 380.) A state tax commission was created as early as 1897. The powers of this commis-

*Engineer, Railroad Commission of Wisconsin and Wisconsin Tax Commission; Professor of Railway Engineering, University of Wisconsin.

sion were extended by successive legislatures until 1905 when the permanent State Tax Commission was organized on its present basis. The tax commissioners are appointed by the governor to eight-year terms. The present commissioners are: Judge N. S. Gilson, chairman, George Curtis, Jr., and Nils P. Haugen, all of whom have served in a similar capacity since February, 1901.

2. **THE RAILROAD COMMISSION LAW.** (Wis. laws, 1905, chap. 362.) This law created the Railroad Commission of Wisconsin and defined its powers with reference to the regulation of rates and service of the common carriers of the state. With certain extensions enacted in 1906 and 1907, the law was made to apply to railroads, street railways, express and telegraph companies. The term of the commissioners' office is six years, with appointment by the governor. The present commissioners are: Prof. Balthasar H. Meyer, Halford Erickson and John H. Roemer.

3. **THE STEAM RAILROAD AD VALOREM ASSESSMENT LAW.** (Wis. laws, 1903, chap. 315.) This law provides for the taxation of steam railroads or common carriers incorporated under the general railroad law on the ad valorem plan instead of the gross earnings basis which had prevailed for many years previous to 1903.

4. **THE STREET RAILWAY AD VALOREM ASSESSMENT LAW.** (Wis. laws, 1905, chap. 493.) This law substitutes the ad valorem for the gross earnings basis in the taxation of so-called "street railway" properties and such lighting and heating plants as may be operated in association therewith.

5. **THE PUBLIC UTILITIES LAW.** (Wis. laws, 1907, chap. 499.) This law confers upon the Railroad Commission regulative powers similar to those of the 1905 Railroad Commission law, applicable to all properties engaged in the conveyance of telephone messages or in "the production, transmission, delivery or furnishing of heat, light, water or power either directly or indirectly to or for the public," and whether publicly or privately owned and operated.

6. **STOCK AND BOND ISSUE LAW.** (Wis. laws, 1907, chap. 576.) This law provides for supervision by the Railroad Commission of the issue of stocks and bonds of "public service corporations."

7. **"PUBLIC CONVENIENCE AND NECESSITY" LAW.** (Wis. laws, 1907, chap. 454.) This law provides that a railroad corporation must secure from the Railroad Commission, in advance of construction or other preliminary step, a "certificate that public convenience and a necessity require the construction of said railroad." Among the powers conferred upon the Commission is the control over the manner of crossing other railroads.

8. **"TWO-MILE" INDUSTRY-TRACK LAW.** (Wis. laws, 1907, chap. 352.) This law provides for the construction of tracks to industries located within two miles of a railroad, at the expense of the owner of the industry, provided the operation of the track would not be "unusually unsafe and dangerous." Provision is made for appeal to the Railroad Commission where railroads upon application refuse to construct such tracks.

9. **THE WISCONSIN VALLEY IMPROVEMENT ASSOCIATION LAW.** (Wis. laws, 1907, chap. 335.) This law authorizes the formation of an association of all owners of water powers along the Wisconsin river for the purpose of establishing extensive reservoirs at the headwaters for the conservation of the water supply. Provision is made that certain reports covering the affairs of the association be submitted semi-annually to the Railroad Commission and that certain administrative functions be performed by the Commission.

The services of an engineering staff are also occasionally brought into requisition under other Wisconsin laws besides those outlined above. Among these may be mentioned the law relating to the protection of railroad crossings and drawbridges and that providing for the installation of bridge warnings or tell-tales.

ORGANIZATION OF ENGINEERING STAFF.

The staff engaged in the 1903 steam road valuation work was organized under three general heads or chiefs of departments, respectively responsible to the chief engineer for the valuation of the permanent way, the lands and the mechanical features. With the reorganization for the purpose of making the street railway valuations, there were still but three heads, the land valuations being associated with the "roadway" group, and an electrical department added. Under the still wider scope to the work of the staff arising under the administration of the public utilities law within the past year or so, the civil and mechanical engineering groups have been extended to cover water-works plants, the electrical engineering group to include telephones, and two additional groups or departments have been established, viz., gas engineering and the department of gas and electric service inspections.

In its present form the working organization includes the following groups or subdivisions: (1) Administrative, (2) office staff, (3) civil engineering staff, (4) mechanical engineering staff, (5) electrical engineering staff, (6) gas engineering staff, (7) gas and electric service inspections, and (8) miscellaneous. The duties of these several departments of service as outlined below cover all phases of the work of the two state commissions.

OUTLINE OF ORGANIZATION OF ENGINEERING STAFF.

1. *Administrative.* Consisting of the engineer, assistant engineer and heads of departments, responsible for the direction of the work.

2. *Office Staff.* Engaged in the reduction of field notes, the compilation of valuation and other reports, and the systematic collection and filing of cost data and other records.

3. *Civil Engineering Staff.* Engaged in the inspection and valuation of those details of the physical property of steam and electric railways and public utilities plants which are customarily purchased, constructed, or maintained under the direction of civil engineers; including such items as the following: Lands, track, track structures and bridges; buildings and miscellaneous structures, such as gas holders, stand-pipes, reservoirs, dams, wells and foundations; earthwork and paving; pipe distribution systems for water, gas and steam heating plants including tunnels for same; office furniture and appliances; horses and wagons; tools, stores and supplies pertaining to the foregoing items; etc. Also investigations, in co-operation with other departments, with a view to suggest improvements in the operating conditions of railways, water-works plants, etc.

4. *Mechanical Engineering Staff.* Engaged in the inspection and valuation of those details of the physical property of steam and electric railways and public utilities plants which are customarily purchased, constructed or operated under the direction of mechan-

ical experts or engineers; including such items as the following: Power plant machinery and equipment (exclusive of electrical features); steam and hot water plants (except street mains); steam road locomotives and rolling stock; shop tools and machinery; tools, stores and supplies pertaining to the above items; etc. Also investigations, in co-operation with other departments, with a view to suggest improvements in the operating conditions of water-works, heating plants, power plants, etc.

5. *Electrical Engineering Staff.* Engaged in the inspection and valuation of those details of the physical property of steam and electric railways and public utilities plants which are usually constructed, purchased or operated under the direction of electrical experts or engineers, including electrical machinery and appliances in power plants and elsewhere; electric railway rolling stock; electrical distribution systems, overhead and underground; telephone plants; signaling appliances; tools, stores and supplies related to the above items, etc. Also investigations, in co-operation with other departments, with a view to suggest improvements in the operating conditions of electric railways, power plants, telephone properties, etc.

6. *Gas Engineering Staff.* Engaged in the inspection and valuation of machinery and appliances for the manufacture of gas; tools, stores and supplies pertaining to the same; etc. Also investigations, in co-operation with other departments, with a view to suggest improvements in the operating conditions of gas plants.

7. *Gas and Electric Service Inspections.* Engaged in inspections and investigations of gas and electric service; studies with reference to the establishment and revision of standards of service and the formulation of rules for the same; tests and calibrations of instruments used in service measurements; investigations with reference to the electrolysis of water and gas mains; etc. Also investigations, in co-operation with other departments, with a view to suggest improvements in the operating conditions of gas and electric plants.

8. *Miscellaneous.* Experts engaged temporarily for special service of various kinds, either independently or in co-operation with one or more of the foregoing departments. Such service hitherto rendered has included such matters as the following: Consultation with prominent architect relative to valuation of a costly city building; service of expert in investigations as to the safety of an important bridge; expert valuation of the horses, harness, etc., belonging to a large electric railway and lighting company; expert assistance in establishing a basis for valuing street railway special work; etc.

The basis of appointment of the staff is provided for in part by a formal rule of the Civil Service Commission, and in part by special authorizations given from time to time by the Railroad Commission for the employment of experts under the provisions of

the public utilities and railroad commission laws. The designations or titles of the staff members is given below :

Engineer in Charge (for the two commissions).

Consulting Engineer (for occasional service).

Assistant Engineer (office engineer).

Civil Engineer Inspector.

Chief Mechanical Inspector.

Chief Electrical Inspector.

Expert on Light and Heat.

Field Civil Engineer Inspector.

Field Mechanical Inspector.

Field Electrical Inspectors.

Inspector of Gas Service.

Inspector of Electric Service.

Assistant Inspectors of Gas and Electric Service.

Assistant Field Inspectors.

Experts (for occasional service).

Engineering Computers.

Clerks and Stenographers.

For reasons of economy or efficiency it has been found expedient in some cases temporarily to combine, and in still others to subdivide, the duties and responsibilities of certain of the positions given in the foregoing list. At the present time, for example, the assistant engineer performs the duties of office engineer and, in a measure, of the civil engineer inspector as well. Similarly, the expert on light and heat is at present chiefly responsible for the staff work of the two related departments of gas engineering and gas and electric service inspections. The duties of chief electrical inspector, on the contrary, are at present shared by two field electrical inspectors responsible for the inspections and valuations, one primarily of the electrical machinery and rolling stock group, and the other of the electrical distribution systems and telephone properties.

It should be stated that membership on the staff is based upon ascertained fitness for the special service for which the appointment is made. There is entire freedom from political or other influence both in the matter of appointment and in the tenure of position on the staff. The tenure of service has been steady, the roll, except for the additions, being much the same as that established early in 1907. The practice followed by the Railroad Commission in its other departments of service of requiring each employe to report daily the actual hours devoted to the state work, is observed by the technical staff.

The present membership of the technical staff consists almost exclusively of graduates of engineering schools, and about 60 per cent. of the permanent staff are graduates of the University of Wisconsin. Seven members of the regular staff are also members of the faculty of the College of Engineering, University of Wisconsin, among this number being the engineer in charge, the chief

mechanical inspector and the expert on light and heat. Five other members of the teaching force of the engineering college also render occasional service on the commission's staff. It is proper to say in this connection that this is but one of many instances in Wisconsin of active participation by university men in professional service on behalf of the state. Such participation is encouraged by the Board of Regents and President of the University, both on account of a recognized obligation to the state which provides support, and because of the stimulus given to the work of the University through outside contact of this kind.

VALUATION WORK BY THE STAFF.

The valuations reported to the commissions by the engineering staff have been confined throughout to the physical property, without regard to intangible elements. For a given inventory covering the items of any particular property, a definite value is fixed upon a fair basis as to unit prices, etc., and the results are reported by the staff at a definite amount, irrespective of the uses to which the figures are to be applied. These determinations are, by intention, entirely free from bias. Every reasonable effort is made to get at the exact truth in regard to local conditions. The figures are subject to revision upon finding evidence of defects of inventory, errors of judgment or other element likely to vitiate results. After submitting the valuation reports to the commission opportunity is given for further conference and hearing upon any or all items of the physical valuation.

In certain public utilities cases the owners, and in a few cases the cities as well, have employed experts to give testimony on values before the Railroad Commission. In one or two such cases the state engineering staff has submitted to the representatives of the utilities company and the city an "informal" valuation report to serve as a basis for preliminary conference and discussion. This preliminary report, after due consideration in the light of added data and information, is succeeded by the "tentative" valuation report which is submitted to the Railroad Commission as a part of the formal record in the case, to be considered with other evidence. Before making up a final decision in the case the Commission gives the engineer an opportunity to review the record and submit a supplementary report, in which are presented revisions or comments bearing upon the original or "tentative" valuation report.

The valuation work performed by the engineering staff falls under four heads, viz.:

- (1) Valuations of the physical property of the steam railroads of the state.
- (2) Of the street railway and associated properties.
- (3) Of the public utilities.
- (4) Of public service corporation properties in connection with stock and bond issues.

The accompanying tabulation includes the total valuations for one year's work each for the steam railroad and electric railway properties, and all of the physical valuation work thus far reported upon under the public utilities and bond issue laws, the last two classes covering a period of somewhat more than a year's time.

COST OF REPRODUCTION.

	Property New	Present Condition
(a) STEAM RAILROAD PROPERTIES.		
Fifty-two (52) properties aggregating 7,090 miles; inventory date June 30, 1907; fourth annual re-valuation under the 1903 ad valorem law	\$244,128,868	\$196,239,314
(b) STREET RAILWAY PROPERTIES.		
Twenty-four (24) street and interurban properties with ten (10) associated lighting and heating properties; inventory date June 30, 1907; first valuation under 1905 ad valorem law.....	26,783,620	21,208,010
(c) PUBLIC UTILITIES PROPERTIES.		
Twenty-four (24) public utilities properties; varying inventory dates; valuations under 1907 law	6,405,521	5,440,605
(d) FOR STOCK AND BOND ISSUES.		
Five (5) properties valued and reports made under 1907 law	305,576	270,008
	\$277,623,585	\$223,157,937

VALUATIONS OF PHYSICAL PROPERTY OF WISCONSIN STEAM RAILROADS.

The Tax Commission, by authority given in section 27 of the steam railroad assessment law, on June 3, 1903, appointed as its expert engineer Prof. Wm. D. Taylor,* Professor of Railway Engineering, University of Wisconsin. Under instructions from the Commission, Mr. Taylor consulted with Prof. Mortimer E. Cooley, of the University of Michigan, under whose direction the Michigan railroad appraisals of 1900-1901 had been made. Acting upon the information and valuable suggestions furnished by Mr. Cooley, the preliminary plans for the Wisconsin appraisals were developed in a comparatively short time, and certain features of the Michigan methods were improved upon. The most important difference in the basis employed in the two state appraisals related to the method of working out the inventories and to the extent to which the state staff made actual detailed field inspections of the physical property. In the Michigan appraisals the state staff took the initiative in preparing the inventories and made extensive and independent field examinations of the railroad property. This work was then largely duplicated by the companies themselves so as to be able to check up the figures obtained by the state staff, and to an extent a third process was required in the final compilations in order to reconcile the two more or less independent appraisals.

*Professor Taylor served as engineer to the Wisconsin State Board of Assessment until February 1, 1906, when he resigned to become Chief Engineer of the Chicago & Alton Railway. His successor was appointed on July 1, 1906, to serve the two state commissions jointly.

With a view to eliminate this costly and seemingly unnecessary repetition of work the Wisconsin Tax Commission, upon the advice of its engineer, suggested to the representatives of the important lines of the state that the companies undertake to inventory and value their own properties for submission to the Board. To this suggestion the companies readily assented, and in the plan of work subsequently adopted it was arranged that any portion or all of the inventoried property might be reviewed by the state staff, according to the judgment of the Commission's engineer. Such reviews of the valuation when finally made fully confirmed the spirit of good faith with which the representatives of the roads responded to the open-minded attitude of the Commission and its engineer towards the companies; and it may be added that the spirit of fairness inaugurated in the initial appraisals has prevailed throughout the successive annual revisions of the steam road valuations.

In view of the very complete presentation of the methods employed on these earlier steam road valuations heretofore published,* it is deemed unnecessary to give space to a repetition of the same in this connection.

Mr. Taylor, at the conclusion of his report to the State Board of Assessment above referred to, makes the following comment with regard to the matter of keeping the valuations up to date by annual revisions:

It should not ever again be necessary to make as expensive an investigation as this has been to determine the value of the tangible railway property of the state. And if the future assessments for taxation are to be in any wise determined by the value of railway physical property, and if a rate-making railway commission is to be constituted in the state which shall give any weight whatever to the investment in physical property in deciding upon rates for freight and passenger traffic, it will be necessary to keep the appraisal of these properties reasonably well up to date. It has been said that no item of railway property, tangible or intangible, remains constant in value. Traffic and the value of land and terminals fluctuate with the tide of business prosperity. Rolling stock, rail, and structures all depreciate and the roadbed appreciates with use. Thus it seems that with this appraisal as a basis it would be advantageous to work the appraisal of the roads over again annually. Counting upon the assistance of the railroads this can be done with a comparatively small force and at a comparatively small expense.

In line with the foregoing plan the engineer had previously supplied to each railway company a copy of the corrected detail summary sheets pertaining to its property, and early in 1905 also sent to each road two sets of blank report forms relating to the physical property in detail, stamped respectively with the words "Deductions

*See Report of Wisconsin Tax Commission, 1907, pp. 269-293.

from property June 30, 1903, to June 30, 1904," and "Additions to property June 30, 1903, to June 30, 1904." These blanks when filled out and returned to the engineer formed the basis of revisions of the original appraisals of 1903 whereby the valuations were brought up to the second inventory date of June 30, 1904.

With reference to the rate of progress on such work some interest attaches to the "lag" or interval of time elapsing from the nominal date of inventory for the steam road valuations to that of final completion of the valuation report. This interval for the several valuations has varied as follows:

- 1st valuation, inventory of June 30, 1903, 16 months.
- 2nd valuation, inventory of June 30, 1904, 14½ months.
- 3rd valuation, inventory of June 30, 1905, 11½ months.
- 4th valuation, inventory of June 30, 1906, 14 months.
- 5th valuation, inventory of June 30, 1907, 17 months.

In explanation of the above figures, it may be stated that in the initial or pioneer valuations as of inventory date June 30, 1903, there were the unavoidable delays incident to the organization of the staff, the formulation of plans for the work, and other elements entering into the earlier steps of any undertaking of large magnitude. In the annual revisions the chief cause of delay has been the time required by certain railway companies in the preparation of their reports of additions and deductions. The third report (second annual revision) was compiled under exceptionally favorable circumstances. The fourth required a longer time to complete, partly because of a delay in the receipt of reports of property changes on one or two of the larger roads, and in part by the fact that the engineering staff was engaged for the first time in the valuations of street railway properties. The increased time required to compile the fifth and most recent steam road report (as of date June 30, 1907) was due mainly to unusual demands upon the staff in connection with valuations and inspections under the public utilities law late in 1907. By increasing the size of the staff somewhat in one department and assigning certain of the staff members exclusively to the valuations for taxation purposes, it appears that the steam and electric road valuation reports may hereafter be compiled within less than a year of the date of inventory.

PROPOSED REVISION OF METHODS: The plan above described has been followed in each of the several successive annual revisions up to and including the fifth. In the 1903 plan the cost of reproduction was "assumed to be what it would cost to reproduce the road at the average prices prevailing for the period of five years ending June 30, 1902," that is, one year preceding the date of inventory. Through the excellent spirit of cooperation which pervaded the 1903 valuation work a series of unit prices based on the above assumption was worked out and adopted. While it has been practicable to make annual revisions in the unit prices for steel rail and a few similar materials subject to current market quotations,

there have been no systematic revisions in the unit prices with respect to many kinds of the physical property involved in the inventories of these steam road properties. Five years have elapsed since these valuations were undertaken, and during this period there have been many radical changes in the cost of labor and materials involved in railroad construction. Notwithstanding the temporary reaction in prices during the past year or so, it is certain that some important items, such as ties and structural timber, will never resume their former basis of cost.

Another matter which requires careful consideration in this same connection is the advance in land values throughout the state. No account has been taken of this factor in the annual revisions, the land values originally established having been used without change in the annual re-valuations. There is also need to investigate further the matter of ratio of cost of acquiring rights-of-way as compared with the normal or average local land values for other than railroad purposes, and these studies should be carried still further to cover the cost of acquiring lands for terminal purposes in the larger cities.

Recent conferences with railway officials touching the foregoing matters indicate that the railroad companies are desirous of co-operating in any steps designed to maintain the valuations on the high standard established in the original valuation work of 1903-1904. As a result of these conferences and of discussions with the state commissions a critical study of the methods heretofore used in the various Wisconsin valuations and in those of other states is being made by the staff with a view to recommend improvements upon the present practice wherever practicable. It now appears that these revisions of method may be carried into effect, at least in part, in making the next (sixth) steam railroad valuation report.

VALUATION OF MILWAUKEE STREET RAILWAY PROPERTIES.

The steps leading up to the valuation of the street railway properties of the state for the purposes of the two commissions have already been mentioned in the introduction to this paper. The staff as organized in the initial work at Milwaukee in January, 1907, included the following roll:

Engineer of the two Commissions.

Consulting Engineer.

Assistant Engineer.

Chief Roadway Inspector.

Chief Mechanical Inspector.

Chief Electrical Inspector.

Field Roadway Inspector.

Field Mechanical Inspector.

Field Electrical Inspector.

A staff of assistant inspectors, office assistants and stenographers.

Total staff roll, 23 persons.

The more responsible staff positions were filled chiefly from those previously engaged on the steam road valuations of Wisconsin in 1903-1904 and from the staff employed in the 1906 electric railway appraisals at Chicago. Mr. Bion J. Arnold, of Chicago, was called in consultation and arrangements made whereby several members of the special staff previously engaged under his direction in the Chicago valuation work were transferred temporarily for service on the Wisconsin engineering staff. Mr. George Weston, previously assistant chief engineer on the Chicago appraisals, was appointed chief electrical inspector on the Milwaukee work, and field electrical and mechanical inspectors were similarly engaged. Other experts were drawn from various sources, each person being selected with particular reference to his fitness for the intended service. Within three weeks' time after authorization was given to proceed with the work, practically the entire staff were on the ground engaged in the preliminary examinations of the property to be valued.

At the preliminary conference held early in February between representatives of the two state commissions, the city of Milwaukee and the street railway company, it was agreed that the date of inventory should be December 31, 1906, for the purposes of the Railroad Commission and June 30, 1907, for the report to the State Board of Assessment, the latter date being in accordance with the 1905 ad valorem assessment law. It was stipulated by the representatives of the state commissions at this conference that the basis of the valuation of the physical property would be identical except as the inventory and the condition of the property itself might differ at the two inventory dates. It was the original idea that the street railway company should furnish a complete inventory of its property, but certain delays occurred which led to a change in plan whereby the state engineering staff undertook the preparation of the inventory from the company's records and by field examinations. It was roughly estimated at the start that the work could be completed in about three months' time but the actual time required was five and one-half months, the final report being submitted on July 13, 1907.

The classification of the property adopted in this report on the Milwaukee properties was as follows:

- Group 1. Land (right-of-way and other).
- Group 2. Track and Track Structures.
- Group 3. Cars and Car Equipment.
- Group 4. Electrical Distribution System.
- Group 5. Power Plant Equipment.
- Group 6. Buildings and Miscellaneous Structures.
- Group 7. Office Furniture and Appliances.
- Group 8. Tools, Implements and Machinery.
- Group 9. Horses, Wagons and Miscellaneous.

Total of Items 1-9.

Group 10. (See note below).

Total of Items 1-10.

Group 11. Stores and Supplies.

Total of Items 1-11.

Group 12. Paving.

Total of Items 1-12.

NOTE—Group 10 is the addition of a percentage to cover engineering and supervision, interest during construction, contingencies, etc.

The final report included the entire property owned by the Milwaukee companies, known locally as the "Beggs properties," viz., the city railway lines (123.6 miles) and the associated lighting properties (The Milwaukee Electric Railway and Light Co.), the country or interurban railway lines (144.2 miles) and the associated lighting properties at Racine and elsewhere (Milwaukee Light, Heat & Traction Co.), and the Milwaukee steam heating company (The Milwaukee Central Heating Company). One exhibit in the report showed the property classified under the heads "Railway Only," "Light and Power," "Steam Heat," and "Other Property." Another exhibit classified the railway property only under "Operating" and "Non-Operating." A third showed the operating railway property under city lines (T. M. E. R. & L.) and interurban lines (M. L. H. & T.). A fourth classified the non-operating railway property in a similar way. The total physical valuation including all the properties mentioned above for the inventory date of December 31, 1906, amounted to \$18,435,960 for the property now, and \$14,864,849 for the property in existing condition.

PHYSICAL VALUATION OF OTHER WISCONSIN STREET RAILWAY PROPERTIES.

Immediately upon the completion of the formal report upon the valuation of the Milwaukee street railway properties the field work for the valuation of the remaining electric railway lines of the state was undertaken. The size of the staff was somewhat reduced and the organization modified in some respects to meet the varying conditions. Of these additional electric railway lines, numbering in all 22 properties, about one-half are operated in association with public utilities, properties supplying electric light and power service. As already stated, this field work on the street railway properties chanced to be undertaken immediately after the enactment of the public utilities law (July, 1907) and it was then foreseen that the results of such work might ultimately be required by the Railroad Commission in rate complaint cases. In view of this development the methods and basis used in the work were critically reviewed in the light of the experience in the Milwaukee valuations, and certain modifications and improvements adopted. The field work on these remaining electric railway properties occupied a period of about three months and the office work an additional period of approximately two months.

The methods of field work employed on the street railway properties had much in common with those used in the steam road valuations, particularly as regards the details relating to roadbed, track structures, etc. However, the inclusion of so many electric lighting plants with these operating properties placed many features of these street railway valuations upon an identical basis with the utilities valuations. Reference is made to the detail description of these methods given below under the head of public utilities.

An effort was made to have each street railway company throughout the state prepare a detailed inventory and valuation of its own property, as in the case of the larger roads in the 1903 steam road valuation. It was soon found, however, that the smaller electric lines were in much the same condition as were the smaller steam roads in 1903 in that they lacked the records and the requisite skilled staff to prepare these valuation reports. The Milwaukee company, operating roughly one-half the street railway mileage of the state under one management, alone of all the 23 street railway companies concerned in these valuations had the necessary records and staff. It is believed that the Milwaukee company would have submitted its own valuation to the Commission for review had there been sufficient time for its preparation, as in the 1903 valuations of the larger steam roads.

PHYSICAL VALUATIONS UNDER THE PUBLIC UTILITIES LAW.

The following definition of the term "public utility" is quoted (section 1797m-1) to indicate the sweeping character of this law:

The term "public utility" as used in this act shall mean and embrace every corporation, company, individual, association of individuals, their lessees, trustees or receivers appointed by any court whatsoever, and every town, village or city that now or hereafter may own, operate, manage or control any plant or equipment or any part of a plant or equipment within the state, for the conveyance of telephone messages or for the production, transmission, delivery or furnishing of heat, light, water or power either directly or indirectly to or for the public.

The law prescribes (section 1797m-5) that "the Commission shall value all the property of every public utility actually used and useful for the convenience of the public," and further provides that "in making such valuation the Commission may avail itself of any information in possession of the state board of assessment."

As stated above, the methods now employed by the engineering staff in the valuation of the physical property of public utility plants are in many respects in close agreement with those adopted early in 1907 for the valuation of the electric railway properties of the state for the joint purposes of the two commissions. These methods in general embrace the following distinct steps or processes:

1. The preparation of a detailed descriptive inventory.
2. Field examinations of the property by a trained staff.

3. Determination of the "cost new" of each item.
4. Estimation of the depreciation on each item of property.
5. Calculation of the present value.
6. Summing up the detailed valuations by groups.

PRELIMINARY CONFERENCES: As an initial step in each important utilities valuation it is customary for the commission's engineer to hold a joint conference with representatives of the company and the city, at which conference a formal request is extended on behalf of the commission that all interested parties co-operate to the fullest extent possible with the commission's staff in getting at the facts with reference to local conditions. These conferences have, as a rule, resulted satisfactorily and in but few instances have the responsible officials of utilities companies or cities seemed disposed to withhold information and assistance, and then only temporarily.

INVENTORIES OF PHYSICAL PROPERTY: The preparation of preliminary inventories or descriptive check lists of the properties has been entrusted to the responsible officials of the public utilities companies wherever practicable. Although in some cases this process has been found to lead to undesirable delays in the earlier stages of the work, it is believed, in general, to result ultimately in a saving of time. In cases where no inventory is supplied in advance by the company, the engineering staff before taking up the actual field work examines such office records as the company may have and prepares a tentative check list for field use.

FIELD EXAMINATIONS: The field examinations of the physical property begin with a careful checking up of the inventory. For example, after a machine or any other item of property has been identified with respect to the check list, or the omission if any noted, a full description is entered in field note books or on special printed forms. This descriptive record embraces all information which it is practicable to gather through a direct critical examination of the machine itself by trained observers, by inquiry of those long familiar with local conditions, or through other channels. The record includes such matters as the following: A comprehensive description of the machine in its original or new condition; whether new or second hand when installed in its present service; if reconstructed at any time, the extent and character and also the reasons for such reconstruction; date of installation; and also of reconstruction, if any; character of service rendered by the machine, whether severe or moderate, continuous or intermittent, etc.; quality or character of maintenance, whether good, fair or poor; and any other information which may have a bearing in fixing the final value of the item or in judging of its operating value.

Throughout the progress of these field investigations due consideration is given to the fact that the public utilities law provides for periodical re-valuations of each property examined, necessitating a permanent record from the very start. This view of the situa-

tion, coupled with the rate-making feature, has naturally led to an open-minded attitude on the part of the commission's staff and of the interested parties with respect to rectifying any discrepancies discovered in the descriptive record.

REPRODUCTION COST OF NEW PROPERTY: With a view to establish a definite and reliable basis for fixing costs, extensive investigations have been made relative to existing-commercial conditions, with the result that a vast amount of cost data as to the purchase and installation of the various kinds of physical property embraced in the public utilities plants is now available in the confidential records of the engineering staff. This information has been gathered from many sources, one of the most important of these being the actual contracts and other records of costs kept in the offices of the various public utilities companies of the state. The records of the utilities companies are made available to the commission or its authorized agents by the terms of the public utilities law. These records combined with the confidential quotations and cost data of many kinds supplied through direct solicitation by manufacturers throughout the country, provide a substantial basis upon which the unit costs are kept up to date. In responding to the requests for information, the manufacturers in a number of instances have found it necessary to carry on considerable research work. In such cases it has been the practice to offer to defray the necessary clerical expense involved in compiling the desired information. In but few instances, however, have these offers of reimbursement been accepted. The invaluable assistance thus extended by the manufacturers is believed to have resulted not only from their being frankly and fully informed at the outset as to the special purposes for which the information would be employed, but also because of their desire to co-operate in an important public movement based primarily upon substantial justice to all concerned. It scarcely need be said that the figures obtained from manufacturers are treated as confidential and used only for the specific purposes for which they were solicited.

It should be stated in this connection that the utilities companies of the state have shown but little disposition to interfere with this free co-operation on the part of the manufacturers. In the very few instances where such interference has actually been noted, the utilities officials have usually been quick to respond to the suggestion that such action was not only short-sighted, but also in direct violation of the spirit of fairness pervading this entire matter. In like manner, citizens and officials of certain cities of the state where a feeling of antagonism had previously developed against certain public utilities companies have in a number of instances desisted from what seemed to be an effort to withhold essential facts required by the engineering staff.

In addition to the sources of information above referred to, the members of the staff have been able to supplement their personal

records of cost data through many voluntary contributions from the professional notes of prominent engineers and by figures gathered from publications of technical societies, the columns of trade and technical journals, etc. Reference may also be made to the accumulation of valuable data included in the sworn testimony given by experts at the formal hearings of the commission.

In order to avoid extreme variations in unit prices due to the fluctuations in market quotations and also with a view to approximate as closely as practicable the conditions which usually prevail in building up public utilities properties, it has been the practice of the staff to use average prices for a term of years rather than to apply the current quotations or unit costs prevailing at the actual date of inventory. For this purpose the average price for the five-year period immediately preceding the date of valuation has been used whenever in the judgment of the staff such rule was practicable.

DEPRECIATION OF VALUE: In determining the allowance to be made for depreciation in value, due consideration is given by the staff to the actual condition of each machine or other item of the property, taking into account the age of the device in connection with its probable ultimate efficient life, the character of the service, the standard or quality of maintenance, and such other elements as may aid in reaching a reliable judgment in the matter. In the steps leading up to such final conclusions, accumulated experience with reference to closely similar property, maintained to a like standard and operated under identical or similar conditions as to service, etc., receives due consideration. An individual item of physical property is judged with reference to its agreement with or departure from the average of such related group or class of property in fixing the probable useful life and in estimating the depreciation. Results obtained by this method in the valuation of physical properties of Wisconsin railroad and public utilities companies, aggregating many millions of dollars, have established the trustworthiness of the method here described.

THE PRESENT VALUE: The depreciation percentage is customarily applied against the "net" or "service value" found by deducting the "scrap" or "residual value" from the "new value," and the so-called "present value" is determined in the usual way by combining the scrap value and the depreciated service value. The treatment of scrap values has perhaps been carried somewhat beyond the degree of refinement customarily used by most engineers engaged in water-works and other like appraisal work, although, it is believed, not beyond what is consistent and proper, considering the magnitude and permanence of these Wisconsin valuations. However, undue refinements in this respect are guarded against, and in cases where the scrap value is slight or much in doubt, the depreciation percentage is applied directly to the cost new to determine the present value.

SUMMING UP BY GROUPS: The classification of the physical property by groups is based as far as possible upon actual similarity of items or similarity of use. Following are illustrations of the tentative groupings employed in the reports of physical valuations thus far submitted to the Commission in rate cases or for other purpose under the public utilities law:

CLASSIFICATION SCHEMES USED IN REPORTS OF TENTATIVE VALUATIONS OF PUBLIC UTILITIES PROPERTIES SUBMITTED TO THE RAILROAD COMMISSION OF WISCONSIN BY THE ENGINEERING STAFF.

For Water-Works Properties:

1. Land.
2. Wells, Intake and Suction.
3. Stand-Pipes and Reservoirs.
4. Distribution System.
5. Pumping Plant Equipment.
6. Buildings and Miscellaneous Structures.
7. Office Furniture and Appliances.
8. Tools, Implements, etc.
9. Horses, Wagons and Miscellaneous.
Total of Items 1-9.
10. (See note below.)
Total of Items 1-10.
11. Stores and Supplies.
Total of Items 1-11.
12. Paving.
Total of Items 1-12.

For Gas Properties:

1. Land.
2.
3. Holders.
4. Distribution System.
5. Power Plant Equipment.
6. Buildings and Miscellaneous Structures.
7. Office Furniture and Appliances.
8. Tools, Implements, etc.
9. Horses, Wagons and Miscellaneous.
Total of Items 1-9.
10. (See note below.)
Total of Items 1-10.
11. Stores and Supplies.
Total of Items 1-11.
12. Paving.
Total of Items 1-12.

For Electric Light and Power Properties:

1. Land.

2.
3.
4. Distribution System.
5. Power Plant Equipment.
6. Buildings and Miscellaneous Structures.
7. Office Furniture and Appliances.
8. Tools, Implements, etc.
9. Horses, Wagons and Miscellaneous.
Total of Items 1-9.
10. (See note below.)
Total of Items 1-10.
11. Stores and Supplies.
Total of Items 1-11.
12. Paving.
Total of Items 1-12.

For Combined Gas and Electric Properties:

1. Land.
2. Intakes.
3. Holders.
4. Distribution System.
5. Power Plant Equipment.
6. Buildings.
7. Office Furniture and Appliances.
8. Tools, Implements, etc.
9. Horses, Wagons and Miscellaneous.
Total of Items 1-9.
10. (See note below.)
Total of Items 1-10.
11. Stores and Supplies.
Total of Items 1-11.
12. Paving.
Total of Items 1-12.

For Combined Water, Gas and Electric Properties:

1. Land.
2. Wells, Intake and Suction
3. Filters, Reservoirs and Holders.
4. Distribution System.
5. Power Plant Equipment.
6. Buildings and Miscellaneous Structures.
7. Office Furniture and Appliances.
8. Tools, Implements, etc.
9. Horses, Wagons and Miscellaneous.
Total of Items 1-9.
10. (See note below.)
Total of Items 1-10.
11. Stores and Supplies.
Total of Items 1-11.

12. Paving.

Total of Items 1-12.

For Combined Electric Railway and Light Properties:

1. Land (Right of Way and Other).
2. Track and Track Structures.
3. Cars and Car Equipment.
4. Electrical Distribution System.
5. Power Plant Equipment.
6. Buildings and Miscellaneous Structures.
7. Office Furniture and Appliances.
8. Tools, Implements, etc.
9. Horses, Wagons and Miscellaneous.

Total of Items 1-9.

10. (See note below.)

Total of Items 1-10.

11. Stores and Supplies.

Total of Items 1-11.

12. Paving.

Total of Items 1-12.

For Telephone Properties:

1. Land.
2. Exchange Equipment.
3. Telephones and Appliances.
4. Distribution System.
5. Power Plant Equipment.
6. Buildings and Miscellaneous Structures.
7. Office Furniture and Appliances.
8. Tools, Implements, etc.
9. Horses, Wagons and Miscellaneous.

Total of Items 1-9.

10. (See note below.)

Total of Items 1-10.

11. Stores and Supplies.

Total of Items 1-11.

12. Paving.

Total of Items 1-12.

Note. Addition of percentage to cover engineering and supervision, interest during construction, contingencies, etc.

OTHER VALUATION WORK.

In addition to the railroad and public utilities valuations covered by the foregoing description, the engineering staff by special instructions from the Railroad Commission has made a number of valuations of "public service corporation" properties under the terms of the stock and bond issue law of 1907. These valuations have been based upon detailed inventories, but in most instances it has not been necessary to enter into the refinements called for in the more

formal valuations. Only five cases of this class of valuation are included in the tabulated "summary of recent valuations." Two other properties, one involving values of large magnitude were valued approximately for bond issue purposes, in advance of the completion of the more exact physical valuation for the primary purposes of the Tax Commission. A few approximate valuations of utilities properties have also been made by the staff under special instructions from the Tax Commission to assist in the more equitable apportionment of values between adjacent assessment districts. The Railroad Commission has received a number of informal requests for valuations of utilities properties intended to serve as a basis for preliminary negotiations between cities and utilities companies looking towards the municipal purchase of such plants. Curiously enough, several requests or inquiries of this sort have reached the Commission indirectly from a neighboring state.

SERVICE INSPECTIONAL WORK BY THE ENGINEERING STAFF.

In exercising the broad powers conferred upon it with respect to service regulation of railroad, express, telephone, and the municipal utilities companies, it has been the uniform policy of the Wisconsin Railroad Commission to insist upon adequate service, but without undue intrusion upon the routine of actual management. The inspections of service made by the technical staff under instructions from the Commission are directed primarily to the actual results. When the results are found to be unsatisfactory, the Commission frankly reports the facts to the company and also to the complainant if any, with such recommendations or suggestions as may seem necessary or desirable. In the more important matters publicity is usually given through the daily press in order that the general public may be kept fully informed. Such publicity is often the only means of fixing in the public mind the responsibility for poor management or in establishing substantial justice where there have been false reports or wrong impressions as to the facts. As a general rule, the suggested improvement of service is made by the management without contest or delay. In the exceptional case the Commission does not hesitate to use the mandatory powers conferred upon it by statute.

RAILROAD SERVICE INSPECTIONS.

The Railroad Commission of Wisconsin has not as yet adopted the plan of employing special inspectors to engage exclusively in investigations of railroad service, although such inspectors may ultimately be required with reference to certain of the more technical phases of railway operation. Provision is made by the law for the employment of the requisite expert help when the need for the same arises. Such matters are at present investigated by the engineer personally or by special assignments from the technical staff, and reports submitted for the information of the Commission.

An interesting experiment recently inaugurated by the Commission is intended to bring together accurate information regarding the railroad service of the state as seen by the ordinary or casual passenger. Under special instructions from the Commission each member of the technical staff submits written trip reports covering his observations while enroute about the state on valuation work or other Commission business. The character and scope of these observations are indicated by the headings given below, taken from a blank form prepared with a view to secure some degree of uniformity in the facts thus reported to the Commission.

TRIP INSPECTION REPORT.

ENGINEERING STAFF, RAILROAD COMMISSION OF WISCONSIN.

Report by Observations on Train No., ...
 Ry. Between (.... M) and (.... M)
 190 .

(Use additional sheet if more space is needed.)

TRAIN SERVICE: 1. RUNNING SCHEDULE. On time or late; if late, actual amount and amount slated, causes, etc. Speeds; etc.

2. TRAIN EQUIPMENT. Coaches; number and kind; crowded or otherwise; cleanliness, ventilation and sanitary condition (cars and toilets). Sleepers.

3. TRAIN EMPLOYES. Engineer; care in running, testing air, etc. Conductor, brakemen, flagman, etc.; treatment of passengers, calling stations, guarding rear end, etc. Pullman and dining car service.

STATION SERVICE: 4. EMPLOYES. Agent, baggageman, caller, etc. Conduct, attentiveness, intelligence, announcing trains, etc. (Give names of stations.)

5. STATION. Waiting rooms and toilets; cleanliness, sanitary condition, ventilation, heating, etc. Platforms; grounds, waiting shelters, etc.

MISCELLANEOUS: 6. Track; bridges; crossings (obstruction or protection); safety appliances; train connections at junction points, etc.

PASSENGERS: 7. Deportment; demands on employes; hand baggage, etc.

(Date) (Sign)

It should be stated that the initial instructions regarding these trip reports were given in such manner as to make it plain that the observer was not expected to engage in "detective" work and that, at least until further instructions were given, the observations and comments were to be only such as might reasonably be made by any ordinary traveler at any station or on any train. Many of the comments in these reports are of an entirely favorable character, as they obviously should be to represent the actual conditions in many instances. The intermingling of these favorable comments with the

often pointed criticisms as to defects of service gives emphasis both to the good and the bad features and commands the attention and respect of the railroad management. A tabulated summary of the trip reports is prepared covering each month's observations and a copy of the monthly summary transmitted to the general manager or other responsible official of each road concerned with such report. The responses of the railroad companies indicate entire readiness on their part to co-operate in this movement for the betterment of the railroad service of the state.

However, these casual observations are not intended in any sense to do away with inspections of a more technical and rigid kind. It is found in practice that the need for the more searching inquiry is often revealed in the course of the routine investigations above described. Under the Wisconsin law and practice the members of the inspectional staff purchase tickets and travel like other passengers.

PUBLIC UTILITIES SERVICE INSPECTIONS.

Among the earliest matters to claim the attention of the Railroad Commission in the execution of the public utilities law was the question of units and standards of service and tests of meters. The sections of the law relating to this phase of the subject are as follows:

Units of Product of Service. Sec. 22. The commission shall ascertain and prescribe for each kind of public utility suitable and convenient standard commercial units of product or service. These shall be the lawful units for the purposes of this act.

Standard Measurements; Accurate Appliances. Sec. 23. (1) The commission shall ascertain and fix adequate and serviceable standards for the measurement of quality, pressure, initial voltage or other condition pertaining to the supply of the product or service rendered by any public utility and prescribe reasonable regulations for examination and testing of such product or service and for the measurement thereof.

(2) It shall establish reasonable rules, regulations, specifications and standards to secure the accuracy of all meters and appliances for measurements, and every public utility is required to carry into effect all orders issued by the commission relative thereto. * * *

Sec. 24. (1) The commission shall provide for the examination and testing of any and all appliances used for the measuring of any product or service of a public utility.

* * *

Public Equipment for Tests. Sec. 25. The commission may purchase such materials, apparatus and standard measuring instruments for such examinations and tests as it may deem necessary.

It was early seen that the proper administration of the foregoing provisions of the law would necessitate the establishment of a central laboratory equipment for the purpose of investigating the various kinds of public utilities service, with a view to the fixing of legal units and standards and also to putting the same into practice on a permanent and uniform basis throughout the state. After some preliminary discussions and conferences, arrangements were made whereby the laboratory facilities of the University of Wisconsin were made available for the purposes of the Railroad Commission, with the understanding that there should be reciprocal use of the instrumental equipment to be purchased subsequently by the Commission. The readiness with which this fortunate arrangement was effected was due largely to the long established policy of the University of Wisconsin with reference to serving the state in every possible way, and the negotiations were greatly simplified by the close relationship existing between the Chairman of the Commission and the University. Following closely upon the agreement above mentioned, the co-operation of the U. S. Department of Standards at Washington was secured and definite arrangements made whereby the standards used in the administration of the Wisconsin public utilities law shall be subject to verification and control with reference to the official government standards at Washington.

GAS AND ELECTRIC SERVICE INSPECTIONS.

The arrangements above outlined, it should be explained, while intended to apply to any phase of the question of units or standards which might arise under the utilities law, were most directly of use to the Commission in connection with gas and electric service, concerning which the necessity of establishing standards first arose.

With the beginning of active inspectional work in the testing of gas and electric service, it became necessary to provide special field equipments which soon took definite form as "traveling laboratories." Strong traveling cases were fitted out with straps to hold the instrument boxes in place and thick padding to protect the same in shipment. These cases are sent by express and the equipment is insured against damage in transit.

With a view to gather data for the intelligent formulation of the rules and regulations mentioned in section 23 of the law, above quoted, a provisional staff was organized and a series of tests of gas and electric service undertaken in a number of the cities of the state. After some progress had been made in this investigation a general conference or hearing was held (March, 1908) at which the owners and operating officials and experts of the various gas and electric companies of the state were given an opportunity to express their views. The program or outline of these discussions included the following points:

February, 1909

GAS SERVICE.

- I. Accuracy of Meters.
 1. Method of testing.
 2. Limit of error allowable.
- II. Calorific Value.
 1. Importance.
 2. Method of testing.
 3. Minimum value.
 4. Variation allowable.
 5. "Gross" or "net" values.
- III. Candle Power.
 1. Importance.
 2. How defined.
 3. How measured.
 - a. Kind of photometer.
 - b. What standard.
 - c. What kind of burner.
 4. Minimum value.
 5. Variation allowable.
- IV. Composition.
 1. Restriction as to impurities.
 - a. Ammonia.
 - b. Sulphur-total.
 - c. Sulphur as H_2S .
 - d. Diluents.
- V. Installation.
 1. Safety.
 2. Adequacy.
- VI. Pressure.

ELECTRIC SERVICE.

- I. Accuracy of Meters.
 1. Method of testing.
 2. Limit of error allowable.
- II. Uniformity of Voltage.
 1. Allowable variation from normal.
 2. Interruptions.
- III. Lamp Efficiency.
 1. What provision for lamp renewals.
 2. Voltage.
- IV. Installation.
 1. Safety.
 2. Voltage limits.
 3. Adequacy of wiring.

In addition to those directly representing Wisconsin interests, there were present at this conference gas and electrical experts from other states and also an official representative of the government bureau of standards.

The proceedings of this conference were supplemented by communications received from other sources and further important information was gathered from the tests of service throughout the state. After giving careful consideration to all available information the Commission proceeded to formulate a set of rules which were officially adopted on July 24, 1908, to become effective three months thereafter (see Decision No. U-21, "In re Standards for Gas and Electric Service in the State of Wisconsin"). These regulations consist of some twenty-five rules classified as follows: Gas Service: (1) Accuracy of meters, Rules 1-7; (2) heating value, rules 8, 9; (3) candle power (no rule); (4) gas pressure, rules 10, 11; (5) purity of gas, rules 12, 13. Electric Service: (1) Accuracy of meters, rules 14-21; (2) regulation of pressure and control of service, rules 22-25.

Lack of space forbids quoting these rules in full in this paper, but reference should here be made to an important departure from usual practice, consisting in the adoption of the heating value as a test for the quality of gas to the exclusion of the customary photometric or candle power test. The rule referred to is given below:

Rule 8. The company furnishing gas which, within one mile radius from the distribution center, gives a monthly average total heating value of not less than 600 B. T. U., with a minimum which shall never fall below 550 B. T. U., may be considered as giving adequate service as far as the heating value of the gas is concerned.

The reasons for abandoning the candle power requirement in favor of the heating value is explained as follows (Wis. R. R. Com., Decision No. U-21, pp. 18-21):

Under conditions governing the use of gas in Wisconsin, it appears that by far the largest amount is used for purposes such that its heating value is a measure of the serviceable value of the gas. There is a small percentage of gas consumption, believed to be materially under ten per cent., which is used in open flame burners, and in which the candle power is a measure of its value. Since the gas so used is but a small percentage of the total, and this percentage is continually decreasing, due to the increasing use of the incandescent mantles, it appears that a calorific standard may be of far greater service than is the commonly used candle power standard. * * * * * For the reasons previously outlined, it appears that the candle power standard which has been almost universally used in the past for gas measurement, is of minor importance in this state. It is possible to secure a high candle power gas which has but a moderate heating value, and to require companies to maintain a double standard which shall insure both the high heating value and a high candle power, would surround them with such restrictions that economy in manufacture might not be attained; and since but few consumers would be benefited by a candle power restriction, and with this number continually decreasing, no regulations as to candle power are prescribed at this time. It should be added, however, that with a 600 B. T. U. heating standard, and in view of the conditions under which gas is being manufactured in this state, a fairly satisfactory illuminating value is insured. It is hardly possible to manufacture a coal gas of 600 B. T. U. which shall not have a candle power from 12 to 16, or even more. The enrichment of a water gas up to 600 B. T. U. will insure an even higher candle power.

The following quotation from the order promulgating these rules and regulations illustrates the attitude of the Commission with respect to their enforcement:

February, 1909

If any management anticipates or experiences difficulty in complying fully with such rules and regulations, it is expected that application for a modification of the rule or rules with regard to which difficulties are encountered will be made to the Commission; but until a modification of any rule or regulation herein prescribed has been expressly authorized by the Commission, the gas and electric companies will be expected to comply strictly with the terms of every rule and regulation ordered herein. It is possible that certain plants are operated under conditions which make it impracticable or not to the best interest of the public to meet all the requirements of all the rules. Under such conditions it devolves upon the utility to show to the Commission, by complete and convincing evidence, that a modification of some rule or rules should be made. Suggestions and criticisms are at all times welcomed by the Commission.

The following brief summary of the progress made in the gas and electric inspectional work is quoted from a report upon the work of the engineering staff for the fiscal year ending June 30, 1908:

The work performed by the special staff of experts engaged in inspections of gas and electric service consisted in the study of conditions existing in various cities of the state and included observations on the accuracy of consumers' meters; the accuracy of methods employed by gas and electric companies in standardizing such meters; the quality of gas as shown by chemical composition and heating value; the pressures at which gas was being delivered to consumers; the pressures and variations in pressure on electrical distribution systems; the efficiencies and deterioration of incandescent lamps; and various other factors relating to adequacy of service. Laboratory investigations have also been made on methods suitable for measuring quality of service, including a study of calorimeters suitable for determining heating values of gas. Special attention has also been given to the investigation of complaints of consumers to determine what factors are the more frequent causes for dissatisfaction. The aims of the work have been to furnish information useful in arriving at the operating values of certain gas and electric plants, to determine to what extent complaints of service made by consumers can be taken as a criterion of the quality of the service rendered, and more especially the information was sought as a basis for establishing rules under which the companies may operate so that adequate service may be insured to the consumers.

During the progress of these investigations numerous instances of poor and inadequate service were found. It appears that in the majority of such cases the defective service was the result of ignorance or neglect of the conditions due to the lack of suitable supervision or the lack of instruments necessary for studying the quality of service. It has been found that in various instances the companies have been needlessly hampered by certain municipal regulations, the purpose of which was to insure good service but which were actually ineffective. Numerous instances of poor service have been rectified by the public service companies upon their attention's being called to the particular defects and it has not been unfrequent that such improvements have been made with little or no expense. It has been demonstrated that the consumers themselves are in some measure responsible for the maintenance of adequate service and it has been one of the purposes of the investigation to formulate information serviceable to the consumers in protecting their own interests.

OTHER UTILITIES SERVICE INSPECTIONS.

Inspectional work performed under the utilities law has also included observations as to the quality of service rendered by steam heating plants and investigations as to the accuracy of metering such services; tests of water pressure and of the quality of fire pro-

tection provided; investigations of the accuracy of water meters; tests of service rendered by telephone systems in a large metropolis, in smaller cities, and in the rural districts; etc. Such inspectional work is being systematized as much as possible with a view to utilize the services of each staff member, in carrying on at least the simpler kind of tests, as indicated in the case of railroad travel, while enroute or engaged in a given locality. An important advantage accruing from such informal local contact with the utilities is found in the opportunity thus afforded to the managers of plants to ask questions and make comments which they are often unwilling to put in writing. It is one of the duties of staff members to put such questions into definite form and file the same in the "query box" at headquarters for future consideration by the staff and for the information of the Commission. Plans are on foot for the extension of this "query box" scheme.

MISCELLANEOUS SERVICE BY THE STAFF.

In view of the length to which this paper has already grown, the writer will not enter upon a detailed description of a further line of work of a miscellaneous character which in the aggregate demands a considerable share of time from the staff. The scope and importance of these further matters is indicated by the headings given below. Certain phases of these duties may be described in a future paper.

1. Supervision of interlocking and signaling installations.
2. Investigations of railroad accidents.
3. Investigations as to the safety of track and bridges.
4. Investigations as to the protection or separation of grade crossings.
5. Reports on proposed industry tracks.
6. Examinations relative to proposed railway construction and of newly completed lines in advance of operation.
7. Investigations of street railway service.
8. Investigations in rate cases.
9. Advisory service as to the operation of public utilities.
10. Other service for either commission.

CONCLUSION. Much of the material presented in this paper is drawn by permission from annual reports recently submitted by the writer to the two commissions. It has been found necessary in places to touch upon some matters which are only indirectly related to the work of the engineering staff. In this connection the following reference is made to published discussions by members of the two commissions:

1. By the Wisconsin Tax Commission, discussions in the Biennial reports for 1901, 1903 and 1907. See particularly the discussions by Judge N. S. Gilson, Chairman, relative to the "Judicial View of the (1903) Law and its Administration" (1907 Report, pp. 108-121).

2. "Tax Reforms versus Local Self-Government," by George Curtis, Jr., of the Wisconsin Tax Commission; address delivered at the annual meeting of the Wisconsin Municipal League, at Oconomowoc, Wis., Sept. 3, 1908. (Separate pamphlet to be had upon application.)

3. "Co-Operation between the Railroad Commission and the Municipalities," by Prof. B. H. Meyer, Chairman, Railroad Commission of Wisconsin; address delivered before the Wisconsin Municipal League, at Oconomowoc, Wis., Sept. 3, 1908.

4. "The Wisconsin Public Utilities Law," by Prof. B. H. Meyer, Chairman, Railroad Commission of Wisconsin; address delivered at the annual convention of the National Municipal League and American Civic Association, Pittsburgh, Pa., Nov. 19, 1908.

The writer cannot properly conclude this paper without referring to the degree of enthusiasm and satisfaction felt by the engineering staff in working to the instructions of the two state commissions. These instructions have invariably been to "get at the truth" and the staff has been given all desired freedom as to the method of procedure.

DISCUSSION.

Prof. C. F. Burgess: I have no formal statement prepared with which to supplement the paper which Professor Pence has presented, and will simply take a few moments to speak in general of some of the features of the work of the Engineering Staff of the Railroad Commission, in which I am interested.

This work to which I refer is that provided for by the section of the laws relating to adequacy of service. It became necessary to define adequate service, and the definitions adopted by the Commission were based upon information gathered in various ways and from all available sources. Among other investigations, tests were made in various cities of Wisconsin to show what kind of service was being given by the gas and electric utilities, and also to determine what service it was practically possible for these companies to give.

It was recognized that the quality of service may be designated by the adjectives "good," "adequate" and "satisfactory," and also that these terms are not synonymous.

Good service may be defined as that which can be supplied by up-to-date plants with the best available equipment and operated so as to secure the best practicable regulation. Adequate service may perhaps be considered as differing from good service in that it recognizes the necessity of certain departures, due to local conditions and commercial considerations. For example, it recognizes that a reasonable departure from normal voltage of 110 must be permitted to insure a reasonable investment. Satisfactory service may be considered as that which satisfies consumers, and adequate service and even good service may not necessarily be satisfactory service, since the personal element of relationship between the management and the public must be taken into account. Tact, courtesy and conscientious investigation of complaint, while of great benefit

to both the company and the consumer, can scarcely be secured through any rules which might be adopted.

In defining adequate service there is not much in the way of precedent to serve as a guide. In reference to commercial gas the most common rule is that a gas shall have a certain minimum candle power. Investigation showed that under the conditions generally existing in Wisconsin, such a provision would be of little value, especially where the value of a gas is regulated by its ability to generate heat. Consequently a calorific standard was adopted to the exclusion of a candle power requirement.

In adopting standards for electric service there is even less precedent than in relation to gas service. There are no standard regulations for allowable fluctuation of voltage or allowable depreciation of incandescent lamps.

The question of lamp renewals is of course a question of great importance in connection with adequacy of electric service. Among the standards adopted by the Commission was one providing that each company shall maintain some system of lamp renewals, leaving the choice of the system to the good judgment of the management of the company, it being required that a description of such system being adopted shall be filed with the offices of the Commission. It is believed that the accumulation of the data, based upon observation of the working out of the various plans adopted will make it possible to work out in the future more definite recommendations as to how efficient illuminating service may best be secured.

It is obvious that I have touched upon only a few points connected with our work, but I shall be very glad to go into any matter more fully if requested to do so.

President Loweth: The paper by Prof. Pence and the supplementary remarks by Prof. Burgess are now before you for discussion. It would appear that no one need hesitate to ask such questions as may occur to him, as these gentlemen have shown that their work is of such character, and they have it so thoroughly in hand, as to make them a veritable encyclopædia in all branches of engineering, and of political economy.

Prof. L. P. Breckenridge, M.W.S.E. I am not able to discuss this paper, but, as the president has intimated, these gentlemen are full of information that we are glad to get hold of through courtesies such as they have shown. I think they must have done for Wisconsin what other states may want done; anyway, I think they must have some ideas as to the prices which perhaps we ought to fix on all of these public utilities of various states, which will certainly guide us as engineers, in designing engineering plants, etc. I am very sure that the work has been done with that extreme care with which Prof. Pence always does things, and I am sure that we shall all find it profitable to review and study the work which this Commission is able to present to the Western Society of Engineers, and doubtless it will be of much value to all of us.

Prof. Pence: Many of the public utilities valuations are now before the Commission, with a possibility of a final revision, so that we have not yet been able to estimate the actual cost of making such valuations. There have been expenses connected with the early stages of the utilities work which make these valuations somewhat more costly than they will be later on.

President Loweth: Has not the Commission now accumulated so large a volume of data as to prices and values in general, that the work can be carried on from this time with a much less force than heretofore?

Prof. Pence: The work can be done more rapidly hereafter, I think. We have some hundreds of public utilities valuations ahead of us, while we have only the revaluation work of steam and street railway property. A considerable staff will be required for some time to come to handle the utilities valuations.

President Loweth: If I am rightly informed, the steam railroad companies are required by law to submit, yearly, complete information as to the physical change in their properties. Are the other public utilities companies of the states required to submit similar data?

Prof. Pence: The public utilities properties are required by the law to report annually the additions in construction, and those are to be taken into account and ultimately re-valuations made.

Mr. W. B. Jackson, M.W.S.E. In the case of lumber, where the prices are running up so rapidly, do you use the average of the previous five years, or do you take a figure that will be just for that period?

Prof. Pence: There are extreme fluctuations in most local markets which will make it difficult to determine what is the absolute value of such items, but it appears that there should be a shorter period than five years; two or three years would probably give a better average for lumber.

Mr. Jackson: In that regard I wish to ask if it would not be safe to take two years back, considering the evident tendency upward of lumber, carrying the figure higher than the previous years have carried it?

Prof. Pence: That brings us face to face with a question that has not been definitely determined as yet, viz., whether the valuation under the utilities law is to represent the cost of reproduction under conditions prevailing at the actual date of the inventory or valuation, or extending over a considerable period of time. As stated in the paper, we have had it in mind to avoid the extreme fluctuations of the market prices, especially for such things as track ties, cast iron pipe, copper and similar details of the physical property subject to such fluctuations.

Mr. G. T. Seely, M.W.S.E. There is a tendency at present on the part of the public to reduce the price paid for the service which the public utility corporations render, and I believe there is a movement in Milwaukee toward the reduction in street car fares,

and that the Commission has been asked for advice. I think it is claimed that the Milwaukee railway company has set aside more for depreciation, renewals, and insurance funds, than good practice would warrant. The present tendency is toward the reduction of the rate of fares on urban transportation systems. However, within the last five years the price of all materials has been increased, as shown by the diagrams, and the wages paid the men have increased, and speaking for the railways, the price received for the service rendered has been steadily decreasing, due partly to fare reduction, partly to the extension of transfer privileges, and partly to the extension of the railroads themselves making a longer ride for a single fare. All railway operators have found that the operating ratio has been steadily increasing, therefore the margin between the earnings and the operating expenses has been steadily growing less. This has been brought to mind especially since the business depression last fall. In Massachusetts and Connecticut certain street railway companies have applied to the State Commissions for increases in fares, and these increases in fares have been granted, either by reducing the length of haul for 5 cents or by actual increase in fare from 5 to 6 cents, or by a charge for transfers. This is entirely in the opposite direction from the trend of the public mind, and brings up the question,—how shall these increases be made and on what basis? In that connection, what is a reasonable return on an investment in those properties? I think the law holds that where adequate service is given, the rate of compensation cannot be reduced below the point necessary to insure a reasonable return on the investment, and I would ask if that question has been brought up with the Wisconsin Commission.

Prof. Pence: I regret that I am not at liberty to discuss the questions asked. These matters are in an undetermined state at the present time. Perhaps something may be said in the closure.

Mr. Charles K. Mohler, M.W.S.E. I would like to ask what is the policy or practice of the commission, (or the law in the matter if covered) in case of improvements such as track elevation or depression, and such work in general as the elimination of grade crossings, when required by law or ordinance? Are the roads assessed and taxed for the full additional cost of the work? In some of the states the work of eliminating grade crossings has been taken up systematically and is being gradually carried out. I believe the provision in New York state is for the state to bear one quarter of the expense, the town one quarter, and the railroad one half.

Where a road makes an improvement, either voluntarily or involuntarily, that is of distinct advantage or benefit to the community where located, but which is not primarily of any use or advantage to the road either in securing or handling traffic or earning revenue, it would seem to me no more than justice or good public policy to exempt the added cost to the road, from taxation. In other words, if it is good policy for the state and town to pay half the cost, why would it not be well to go a step farther and exempt

the improvement from taxation? The elimination of grade crossings is of such great importance as to warrant the state in offering every reasonable encouragement and inducement for the railroads to carry out improvements of that nature.

Prof. Pence: I understand the question refers to two things: (1) the apportionment of the construction expense in building the crossing, and (2) the tax on the work when completed. I do not recall that any cases of this kind have been decided by the Wisconsin commissions.

Prof. Breckenridge: I think that the Wisconsin commission have had some difficulty in deciding what would be considered a reasonable life for many engineering appliances and things of that nature, but doubtless they have available on their books many data along this line. It would be interesting if they would publish a list of about fifty or one hundred of such appliances, giving their estimates as to a reasonable life.

Prof. Pence: I shall endeavor to present some information along the line inquired about by Prof. Breckenridge, although these figures are being changed from time to time.

Mr. P. Junkersfeld, M.W.S.E. If I understand Prof. Pence correctly, he said that the commissions had not yet arrived at a decision as to whether or not they would take the replacement value of the property at the time the valuation was made, or whether they would take the actual cost of building that physical property.

In some years the prices may be abnormally high, and in other years the prices may be lower, and it occurred to me that if you oblige those companies to make investments at actual prices as they exist from year to year, the valuations should be made on the basis of prices actually paid, as any other basis would seem to work an injustice to one party or to the other.

Prof. Pence: As already explained there are two commissions; the duties of one commission relate to taxation and of the other to rate making and service regulation. I will repeat the statement given in the paper to the effect that one physical valuation is acceptable for the purposes of the two commissions.

However, I have not answered Mr. Junkersfeld's question directly. The intention is to determine the physical valuation in the light of all available information. If contention is made as to the valuation figures, due consideration is given to any further facts supplied or available to whichever commission has the matter under investigation, and a final revision made by the engineers.

Mr. Junkersfeld: In that same line, I would ask if, in making a valuation, recognition is given to the fact that it costs a good deal more to build up a property piece-meal than to do it all at one time? When property is built up in that way I presume allowance is made for such items as brokerage fees, organization, legal expenses, etc.

Prof. Pence: Careful consideration has been directed to this matter, but definite figures on this point are hard to get hold of. One thing should be kept in mind with reference to such valuation

work: we are dealing with finished properties and we endeavor to have the most perfect inventories that the combined effort of the state engineering staff and of the experts of the utilities companies can produce. In this case there is a difference with respect to the allowance for engineering and contingencies as contrasted with estimates for a new or hypothetical property. The designing engineer, in making his estimates of costs, makes allowance for the fact that when the work is finished he is likely to have a larger inventory than at the outset, partly because his plans and ideas are incomplete at the start. It is interesting to note how much a supposedly perfect inventory of an old property may lack of being complete or perfect.

Mr. W. E. Symons, M.W.S.E. I do not feel able to discuss this valuable subject in detail, but there are one or two points on which I would like information. I have in mind, in asking this information, first: the example of a steam surface railway built some years ago that had been what might properly be termed pretty evenly worn out, and as a result of the actual service conditions it had received renewals and betterments of a permanent character, light capacity and temporary bridges being replaced by heavier permanent ones, locomotives and cars replaced by others of similar or slightly increased capacity, etc., resulting, of course, in some considerable increase in valuation of the property.

The second example contemplates another railway, or some particular sections of the same line, over which the reduction of rates had made it necessary for the company to expend large sums of money in the reduction of grades, possibly abandoning portions of the old line and constructing complete new sections, in order to get a lower grade line, purchasing new and heavier locomotives, new and heavier turntables to handle them, and expensive additions to round houses and shops, all of this in order to give the shareholders some profit on their investment, the sum total possibly amounts to as much as \$10,000 to \$15,000 per mile for practically rebuilding a railway that was not worn out, but that if not so treated would probably show a deficit from operation. My question is, would the commission in making an inspection and placing a valuation, capitalize all the expense incurred in the original and the rebuilt line and authorize bonds to cover that amount, or would it allow only an amount equal to what the present improved line would have cost had it been originally so built and equipped? If on the former basis, then it is not only possible but probable that on a system of some considerable size in territory with diversified traffic conditions, one or more sections may be capitalized at one-third or one-half times, or even twice as much as some other portions of the system, and still not exceed the actual cost necessary to put it in shape to avoid a loss from operation. Would the commission recognize these expenditures and approve the issue of bonds on this basis per mile, or would they either average the entire system or lower the rate on the rebuilt line to the estimated cost of reproduction?

I have in mind another instance where a railway company had spent a considerable amount of money in reducing gradients on a line to meet traffic conditions in a certain direction,—possibly to the extent of three or four thousand dollars per mile. After having done so, the direction of traffic is reversed, making it necessary to spend a similar amount in the other direction. Would both these items be recognized as increasing the legitimate valuation of the property and the company be allowed to make a fair return on the total cost?

Depreciation.—Physical valuation of railway properties I assume includes depreciation of all property. It would be of interest to know about what per cent. of depreciation per year is written off the value of locomotives, cars, shops and tools; in other words, what is considered a fair average life for this property?

Also in case of a railway company finding it necessary to change its form of motive power or method of transportation after having gotten its road into first-class condition, would the increased cost thus involved be considered a legitimate expense item to justify increased capitalization? for instance, if a change was being made from steam to electricity.

Prof. Pence: I do not recall that those matters have come before the railroad commission: They are complex questions, but if anything can be said in answer to them, I shall be glad to include it in my closure.

President Loweth: With reference to the question which Mr. Symons asked, whether the valuation was based on certain small units or sections of the railroad, or upon the railroad as a whole,—if I remember correctly, the valuation of the railroads in Wisconsin is based on small units, and in that case every improvement on a short length of the road would be taken into consideration. Am I not right, Prof. Pence?

Prof. Pence: Yes; but the actual quantities in the inventory of the physical property as of a given date controlled the valuation.

Mr. Mohler: I believe the first work done in this country in getting tax valuations of railroads on the basis of the "cost to reproduce in the present condition" was on the Erie R. R. in New York state. In 1897 a decision was rendered, in a suit brought by the N. Y. L. E. & W. R. R. Co., vs. Clapp and others, Assessors, etc., in New York state, establishing the principle that the railroad property should be appraised on the basis of the "cost of reproduce in its present condition." In the summer of 1899 the real estate department of the Erie R. R. took up the work of valuations and appraisals in New York state. During the summer I was delegated by the chief engineer to take up the work of making surveys and estimates. I made actual field surveys of over 150 miles of line, and estimates were made upon a large portion of that which had been surveyed. In cases where the company were warranted in asking for reductions, I appeared at hearings before the different boards of assessors to give expert testimony. The general conduct and legal part of the

work was in charge of Mr. Harrison Williams, now General Land and Tax Agent of the Erie R. R. The matter of assessing the roads was then and is now in the hands of the local boards of assessors. In some cases reductions were obtained at the hearings before the boards, while in others the boards were served with 'certiorari,' and the cases brought to trial. The net result I believe has been a material lowering in assessed valuations of the road throughout the state.

In making the field survey, account was taken of every tangible item that entered into the construction of the road, and its condition noted. In estimating the rail, the weight, condition and age were noted. The life of the rail was assumed at different periods, varying with the weight of traffic hauled over the line. The scrap value was assumed and the assessed value fixed from the remaining wearing value plus the scrap value. Ties, fencing, and minor timber construction were generally estimated at fifty per cent. of their original cost. That was considered correct owing to the fact that timber begins to deteriorate as soon as it is placed in an exposed construction, and is found in the general make up of the entire line, from that which is worthless to that which has just been renewed. Station and like buildings were seldom given a greater depreciation than twenty-five per cent. Bridges and masonry were given the depreciation called for in the field notes, with an estimated life of fifty years. The right-of-way was estimated at the same value as the adjoining property or that in the immediate vicinity. That, I think, is perfectly just, while the expense of acquiring the right-of-way is usually much more than the market value of the property through which it was acquired, the extra cost is usually chargeable to damage to the property "cut up" and some of it to "hold up." If the broader view of the matter is taken it must be conceded that the presence and operation of a railroad in almost all communities adds greatly to the property values. This is true to such a marked degree in some localities that if the roads serving them were to be abandoned, the property values would shrink to almost nothing.

Railroads should be considered to a certain extent a modern highway and their "public utility" features recognized. The tendency has been, in most localities, to tax them all they would stand. With rate supervision by the civic authorities should go equitable taxation.

Mr. D. W. Roper, M.W.S.E. Many of the public utilities companies in the large cities make a practice of installing underground structures, such as gas pipes or conduits, in advance of street paving. In such cases, where an expensive paving is installed by the city over this underground structure, what relation does the rate fixed by the commission bear to the cost of installation?

Prof. Pence: I regret to say that this, also, is one of the undetermined matters. There are a number of important cases before the commission, in which matters of this sort are involved.

President Loweth: With reference to the question which has just been asked, I suppose that the valuation would stand, with the com-

mission, if it was based on the value of the conduit and of the paving over it.

Prof. Pence: In Milwaukee, the unit prices for electric wire conduits include the paving item. The paving item is figured separately, as a rule, in the utilities valuations when involved with trenching for water works and gas mains.

President Loweth: With reference to the question which Mr. Symons asked, whether the valuation was based on small units or sections of the railroad, or upon the railroad as a whole; the Railroad Tax Commission arbitrarily divided the railroads into small sections of a few miles in length, or the portions contained within the corporate limits of the larger cities, and the values of each of these several sections was determined.

Prof. Pence: Yes, that was the way it was done in the valuation in 1903.

Mr. Symons: If no depreciation had been written off, and if the road has been rebuilt two or three times, then its capitalization, it seems to me, in fairness should represent the sum total of all cost, less a fair depreciation, and my inquiry was to ascertain just what would be included; for instance, in the road which had received only ordinary renewals, and the road which had been rebuilt.

For illustration we will assume a certain railroad to be in good physical condition, and its operation satisfactory alike to its owners and patrons, until new or changed conditions make it necessary to rebuild the line to provide the service demanded and to avoid financial disaster. A large portion of a good railroad must be practically thrown away, the management being forced to rehabilitate the property at great expense, and if no depreciation has been written off during the life of the road, then it seems to me the new line's capitalization should represent the sum total of all expenses from the first, and not what it cost to rebuild the line, as there is a vast difference between what it *may* cost to *reproduce*, and what it *has* cost to produce.

From Prof. Pence's answer to President Loweth's example I would understand that the total cost to produce had been recognized in the 1903 estimates, but what I am especially interested to know is if there is any fixed rule, plan or scheme to be followed in all cases, or is the commission to use its judgment in the different cases coming under its jurisdiction.

Prof. Pence: Mr. Symons has in mind the cumulative idea, as I understand him. The 1903 ad valorem tax physical valuations were based upon inventories as of a given date, and not the cumulative quantities of abandoned or displaced features.

Mr. W. B. Storey, Jr., M.W.S.E. If we take the value of the railroads as of a given date, a railroad embankment five years old is worth more at the time the inventory is taken than when built. In the valuation made by the engineering staff of Wisconsin, is the age taken into account?

Prof. Pence: That was not taken into account in the 1903 appraisal. It is a matter that is under consideration, however, at the present time, in the steam road revision mentioned in the paper.

President Loweth: The speaker assisted in making the first or 1903 valuation of the lines of the Chicago, Milwaukee and St. Paul Railway in Wisconsin. If he remembers correctly, the law required the valuation to show the cost of reproducing the properties as they existed in the 30th day of June, 1903. The valuation was to be based on the average prices for labor and materials prevailing during the five years previous to June 30th, 1902. The several Railroad Companies were required to report to the Tax Commission of Wisconsin, on blanks furnished for the purpose, complete statements setting forth in detail the extent and character of their properties, showing itemized quantities in detail and the prices assumed for each, the age of the various structures and their condition per cent. or depreciation. The time allowed for gathering this data and making the valuation was quite limited, and the magnitude of the task much greater than first assumed; especially as there was no complete inventory of much of the physical properties, and their age, extent, condition per cent. and much of the desired data could only be determined as a result of a survey of the properties.

The difficulty of arriving at the proper prices to assume for the various elements of labor and material was quite perplexing, and necessarily included the multiplicity of various kinds of material and labor entering into all the various details of a completed and operated railroad. If Professor Pence's diagrams of the prices of materials had been available, the work would have been simplified, but it will be noticed that in these diagrams the prices fluctuate not only year by year, but repeatedly, and often fluctuate largely month by month and week by week, and it was not an easy task to determine what were the fair average prices for a period extending over one to six years in the past.

Mr. A. Reichmann, M.W.S.E. Can you price these properties within 25 per cent?

Prof. Pence: It is a well known fact that many of the differences in such valuations are based upon differences in the premises, and these perhaps are established by attorneys representing different interests or points of view. The valuation experts may disagree because of a lack of agreement as to hypothesis or basis for the valuation.

Mr. Storey: In regard to the average of prices for the five succeeding years, I am somewhat uncertain as to whether it is the intent to take the average of those five years and apply it to the coming year, or take the curve of the average and continue the curve to determine the price for the coming year.

President Loweth: The law was quite definite in the matter referred to. As has been stated, the prices to be assumed for both labor and material were to be the average prevailing during the five years previous to June 30th, 1902.

Mr. Reichmann: In regard to assuming the average prices for a period of five years, I do not believe that this is fair, because when the prices are high railroad companies purchase larger quantities of goods; that is to say, they buy more than their normal requirements. When prices are low the reverse is true. Take for instance this year, the railroad companies have not consumed over about 50% of their normal requirements and the prices have been correspondingly low, so the average price would not represent the average cost of the commodities to the railroad company. In order to make this fair it would be necessary to multiply the average consumption for the year by the average price for the year and then make averages of these averages.

Prof. Pence: If it were practicable to secure the necessary data we should be glad to give consideration to a weighted average based upon the magnitude of sales, rather than use open market prices. However, we find it impossible to work it out on the basis proposed by Mr. Reichmann.

Mr. Storey: In connection with the difference in valuation for taxation and rate-making purposes, Prof. Pence dwells on the organization of the staff and the way it is handled in Wisconsin, and possibly he may not wish to give an opinion or to state any facts outside of that, but I would ask for information as to whether there is a status fixed in Wisconsin by the two commissions as to any relation that shall obtain between the valuation of public utilities and railway properties for taxation and for rate-making purposes? Do the commissions recognize a different status for those two purposes, or do they take the same valuation and apply it to both purposes?

Prof. Pence: It should be remembered in this connection, however, that the problem of fixing values for all the railway properties of the state has come directly before but one of these state commissions, viz., the Tax Commission. It is only in a few cases that the other commission has been called upon to use the data already gathered by the Tax Commission, with respect to steam railroad properties.

Mr. Storey: I asked the question with the idea simply of adding to our general knowledge. It is one that will have to be met by all of us sooner or later. As an illustration in point, I have in mind the matter of right-of-way. If a railroad obtains a right-of-way across a man's farm, it has to pay three prices for it, and the railroad should be allowed to earn interest on such cost. The question is, should such a figure as \$150.00 per acre be used as the valuation for taxation purposes, when the farm adjoining is assessed at \$50.00 per acre? Questions are going to continually arise, and I think if any decisions have been reached, it would be of value to us to know about them.

Prof. Pence: In fixing the value of the right-of-way strip in the values fixed in 1903, a ratio of $2\frac{1}{2}$ was employed, as representing the amount which would be necessary to reproduce the property.

For electric roads the ratio was later found to be practically the same as that used for the steam lines.

President Loweth: In the first, or 1903, Wisconsin appraisal, a circular letter was issued by the State Board of Assessment, giving the method by which the values of right-of-way were to be arrived at; it was quite interesting, and if Prof. Pence would embody it in his paper, I think it would add to the interest. Instances were given, as I remember it, in which the values of the right-of-way were from one to two, three and four or more times the values of the adjoining land, and the valuations were based on the various incidental costs in connection with acquiring the property, such as damages, etc., in addition to the actual value of the land acquired.

Mr. Storey: It is my understanding that in Wisconsin they make no difference between the valuation furnished for the taxation board and the valuation for the railroad board.

CLOSURE

Prof. Pence: (by letter.) The writer regrets that some of the questions raised in the discussion cannot be answered at this time, for reasons already indicated. Certain of these questions touch matters at present under consideration by one or both of the state commissions.

The discussion of this paper very well illustrates the varying view-points customarily found in appraisal or valuation work. The points raised by one speaker seem to hinge primarily upon the question of taxation. Other speakers had in mind, apparently, the danger of under-valuation. This difference, touching upon the premises or assumptions adopted in making the valuations, is a fundamental one in all such work. As already explained, the Wisconsin engineering staff, serving the two commissions, has steadfastly sought to hold to a 'middle-ground' position, and it has been assisted in this endeavor by the fact that the physical valuations made by the staff are continually judged and criticised, and often attacked, from the two opposing directions or view-points. Owing to this condition, a certain balance or poise is maintained which, it is believed, could not otherwise be possible.

It should again be stated that the valuations made by the engineering staff and reported to the two commissions as evidence for their consideration, relate solely to the tangible physical property. The intangible elements of value, in so far as they receive consideration, are handled directly by the commissions themselves.

An extensive list of "lives," scrap values and minimum service values used by the staff in the valuation work, are in a process of revision at the present time. It is hoped that these may be wrought into shape for publication in the near future.

MEMORIAL

CHARLES HAROLD TUTTON, M.W.S.E.

June 19, 1908.

Charles Harold Tutton was the eldest son of George and Sarah Henry Tutton. He was born in Tunkhannock, Pa., May 10, 1851, and when eleven years old entered a country printing office where he remained until he was fifteen years of age.

In March, 1867, he entered the service of the Lehigh Valley Railroad in the engineering department, and from 1869 to 1872 he attended the Rensselaer Polytechnic Institute, at Troy, N. Y. Between 1871 and 1873 he located and built the Montrose Railway in Pennsylvania and also worked on railroads in New Jersey. From 1874 to 1877, he was engaged in mining and general engineering with T. A. Stearns, at Wilkes Barre, Pa. In 1878 he was employed in bridge engineering at South Bend, Indiana, and in 1879 returned to Wilkes Barre, where he was engaged in bridge engineering and mining until 1882, when he came to Buffalo where he resided until his death.

Mr. Tutton was connected with the Lehigh Valley Railroad from 1882 to 1888, in charge of the company's work at Buffalo, in connection with the Tifft farm improvements, canals, coal trestles and the shore protection along Lake Erie on the Hamburg turnpike. He also built the company's coal trestles in Chicago. From 1889 to 1892 he was engaged in general work for contractors, who during this time built a number of trestles on the Adirondack and St. Lawrence Railroad, the Lehigh Valley coal trestles at Cheektowaga (the largest in the world), the new Buffalo city reservoir, etc. After 1893 he was connected with the Bureau of Engineering (Department of Public Works), Buffalo. In this capacity he had charge of the erection of the steel liberty pole on the Terrace, city dredging operations, Buffalo river improvements, designing and constructing of the sewer system of South Buffalo, the erection of the bridge over Cazenovia Creek, the city survey, plans for the proposed new water works, etc. In 1889 he was a candidate for city engineer but was not elected.

In December, 1882, he married Fannie C. Draper, of Tamaqua, Pa., who, with three daughters and one son, survives him.

Mr. Tutton was an able and successful engineer, and contributed many articles to engineering magazines, among them, being "Flow of Water Through Pipes," read before the Western Society of Engineers in 1896. He was known throughout the country as a genius in mathematics, and his personal mathematical manuscripts are marvels to all who have seen them.

He was a member of the American Society of Civil Engineers, elected October 2, 1901; of the Western Society of Engineers, from

1877; of the Engineers' Society of Western New York from its organization; and of the American Association for the Advancement of Science.

H. G. TUTTON.

CHARLES A. SMITH, M.W.S.E.

October 20, 1908.

Mr. Charles Arthur Smith, the subject of this notice, was born at Naperville, Illinois, November 11, 1880, and died in Chicago, October 20, 1908, following an operation for appendicitis. He was graduated from the Northwestern College in 1901. He had previously entered the service of the Vandalia Railroad as Rodman in 1898, and after graduation rose to the position of Assistant Engineer for that Company. In 1902 he entered the service of the Chicago & Western Indiana Railroad as Draftsman, and was promoted to Assistant Engineer and finally to Principal Assistant Engineer, holding the latter position at the time of his death. He was elected a member of this society, November 12, 1906.

While with the Western Indiana Railroad Company Mr. Smith was entrusted with constantly varying work of a different and responsible character, which he carried to completion with uniform success. The 51st Street Engine Terminal of that company stands today as an evidence of his ability in planning and handling construction details.

Only those close to him could appreciate his extraordinary gifts of intellect and his sterling character. His fellow employees were all his friends, and they feel a keen sense of personal loss that he is gone.

The sincere sympathy of the members of the society will go out to the wife whom he left, and to whom he was married only a month before his death.

E. H. LEE,
M. K. TRUMBULL,
Committee.

PROCEEDINGS OF THE SOCIETY.
MINUTES OF THE MEETINGS

THE ANNUAL MEETING, TUESDAY, JANUARY 5th, 1909.

The 39th Annual Meeting (being No. 648 of the Society) was held Tuesday evening, January 5, 1909.

The meeting was called to order by President Loweth in the club rooms of the Chicago Athletic Association, at 125 Michigan Avenue, about 7 P. M.

When the secretary read the report from the Judges of Election, the president made announcement of the results as follows:

Andrews Allen was elected President; P. Junkersfeld, First Vice President; O. P. Chamberlain, Second Vice President; W. F. M. Goss, Third Vice President; A. Reichmann, Treasurer; and Geo. M. Brill, Trustee to serve three years; also that W. C. Armstrong and L. E. Ritter would hold office as Trustees for one and two years respectively and be on the Board of Direction, as also the Past Presidents, B. J. Arnold and W. L. Abbott.

By mutual consent, the further business of presenting the annual reports of the treasurer, secretary and librarian was postponed.

The company, 118 in all, then adjourned to the new banquet room where the annual dinner was served.

After the dinner President Loweth addressed the company as follows:

Gentlemen of the Western Society of Engineers and Our Honored Guests.

You are fortunate, and I am much more fortunate, that as our constitution does not require of the retiring president an address, I shall take your time only long enough to present a few figures as to our membership and financial condition; I will then give way to the rich program which our very efficient entertainment committee has provided for us.

The membership of the Western Society of Engineers has not increased during the past year in the same proportion as in some previous years, due perhaps to the financial situation which has prevented many from joining the society who might otherwise have done so. Our membership at this time numbers 993, seven less than one thousand. It is made up of 2 honorary members, 783 active members, 67 associate members, and 141 junior members. During the past year we have received 47 new members; there have been 5 deaths, 26 resignations, and 23 have been dropped from the rolls on account of non-payment of dues. We have lost five members by death, Mr. James Dun, who died February 23, 1908; Mr. Charles N. Tutton, who died June 19, 1908; Mr. E. H. Beckler, who died August 26, 1908; Mr. Charles A. Smith, who died October 20, 1908; and Mr. Ossian Guthrie, who died October 25, 1908.

The total receipts of the society for the past year from membership dues, the Journal, advertising and the like, amount to \$18,232; our expenditures were \$18,398, and that sum includes the expense of our new quarters. You will see that our expenditures exceeded our receipts by about \$200, and it was necessary for your Board of Direction to make a loan of \$1,600, which was made about the 15th of November, for sixty days.

The cash on hand at the beginning of the year was \$1,434. The society has invested in interest bearing securities, \$9,200. Of this amount \$2,000 is made up of the two special funds, one known as the Chanute Medal Fund of \$1,000, and the other as the Arnold Fund of \$1,000. These two funds are separate funds and should be so considered.

During the past year your Board of Direction has completed the work which was begun a year ago by the previous board, of providing new and larger quarters for the society. It hardly seems necessary tonight to describe these quarters to you or to tell you anything about them. Most of you have seen them and they have spoken for themselves. The work that we did cost the society \$6,580. We have almost doubled the floor space that we had previously. We have very much better quarters, much better fitted to the work

and requirements of the society; yet I think that we bid fair in a few years to outgrow the quarters that we have so recently acquired. I might state that we have made a ten years' lease with the agents of the Monadnock Block for the quarters we now occupy, at an annual rental of \$2,500.

During the past year we have held twenty-eight called meetings including the meetings of the Electrical Section, and at these meetings we have had interesting papers which have been profitably discussed. These papers have been of a varied character, covering pretty much the entire range of engineering. I wish, gentlemen, that you older members of the society who attend functions of this kind would be more regular in attending the meetings of the society, for I know that it would be quite helpful to the younger men, who are quite faithful in attending these meetings, and would make the society more useful, and our Journal more interesting and profitable.

You are doubtless all aware that we have what is known as the Chanute Fund; a gift from Mr. Octave Chanute of \$1,000, the income from which is to be used each year in awarding a medal to each of the three most noteworthy papers on engineering subjects. One for the best paper on a subject in civil engineering; one for the best paper on a subject in mechanical engineering, and the third for the best paper on electrical engineering. The papers which have been esteemed the most noteworthy of those presented to the society by members thereof during the year 1907, which is the year covered by the report of the committee, and for which the medals have been awarded, are as follows:

For the best paper in civil engineering; to Professor F. E. Turneure, for his paper on "The Experimental Determination of Stresses in Web Plates and Stiffeners in Plate Girders."

For the best paper in mechanical engineering; to Mr. Walter T. Ray and Mr. Henry Kreisinger, for their paper entitled: "The Nature of True Boiler Efficiency."

For the best paper in electrical engineering; to Mr. D. W. Roper, for his paper on "A Few Unusual Burnouts of Underground Cables."

It appears through some oversight that no formal set of rules governing the award of these medals has been drawn up by the Board of Direction so far. That is one of the matters which should be attended to by the incoming board, so that there shall be a better definition of the character of papers entitled to these awards. The Board of Direction has ordered four of the Chanute medals struck off and will, when received from the maker, award them, accompanied with a proper diploma, to the authors of the three papers.

The constitution of our society provides for four classes of membership: Honorary members; Active members; Associate members; and Junior members. We have had on our rolls, for several years, one honorary member, Mr. L. P. Morehouse, who was the early secretary of the society and who served for a good many years; we have recently added one more name to our roll of honorary members. The Board of Direction at its last meeting received the following petition signed by a large number of members of this society. I will read the petition:

CHICAGO, December 3, 1908.

Board of Direction, Western Society of Engineers, Monadnock Block, Chicago.

GENTLEMEN: The undersigned members, respectfully petition that Mr. Octave Chanute be elected an honorary member of the Society. Mr. Chanute's membership dates back to the year 1869, when the Civil Engineers' Club of the Northwest, the predecessor of this Society, was formed, and he is therefore one of our oldest members. His long career as an engineer has been very honorable and distinguished, and he has always shown a special solicitude for the welfare of our Society, contributing to it liberally of his time and means. His devoted work in the interest of the engineering congresses and the entertainment of visiting engineers during the Chicago World's Fair is well remembered by all those who were fortunate enough to be in attendance on those memorable occasions. He has been signally honored by The Institution of Civil Engineers, the great English national society, which made him an honorary member in 1895. We think it is time that our Society, which

is so largely composed of his neighbors and friends, should show its appreciation of his distinguished merits and honor itself by conferring this honor upon him.

(Signed by more than the necessary number of active members of the Society.)

It is hardly necessary to state that this petition was favorably received by the Board of Direction, and at its last meeting, last week, the board formally acted upon it and duly elected Mr. Octave Chanute an honorary member of the Western Society of Engineers.

I am not able in the short time that is permitted me to say what might be said of Mr. Chanute. You all know him; he is no stranger in our midst, and we have loved him not only for what he has done for us, as a Society, but for what he has done for the great profession of engineering. And now, gentlemen, Mr. Chanute will address you, but before he does so I propose that we all stand and drink Mr. Chanute's health.

Mr. Octave Chanute: Gentlemen, I feel deeply grateful to your Board of Direction and to the members who did me the honor unsolicited and unexpected, to propose my name for honorary membership, as well as to all the members of the society who have thus signified their approbation of the honor done to me in electing me an honorary member of your society. It is perhaps due to the fact that I have lived long enough, and I sincerely wish that all of you may enjoy similar longevity, and that some of you shall eventually arrive at the stage of honorary membership.

I began engineering in 1848, a lad of seventeen, in the original building of the Hudson River Railroad. At that time there were but few engineers in the United States and they mostly upon canal and water-works enterprises. I have lived to see the profession increase very greatly in scientific standing and in public esteem. I have seen this and other engineering societies increase greatly in numbers. I believe that the oldest society of engineers in the world, the British Institute of Civil Engineers was organized in 1828 and has now increased to 8,600 members. The French society, was organized in 1848, the year that I began work, with I think 37 members, has now increased to 3,700 members and there is besides a large and influential engineering society in the Ponts et Chaussées, who are successfully in charge of the public works of France. The American Society of Civil Engineers, which was organized in 1852, with I believe seven or eight members, has now grown to a membership of 4,500, and the Western Society of Engineers which was organized in 1869 with I think three members, has now grown to a thousand. I sincerely hope that it will continue to increase until it reaches the numbers of the German society which I believe has some 10,000 members.

Meanwhile, the profession has grown in standing, in prestige as well as in numbers. That great increase in numbers is probably caused by the fact that these various societies were organized about the beginning of the railway era which, introducing a new mode of transportation, cheaper, more comfortable, and quicker than that then existing, caused great expansion and a great demand for engineers. It is possible that this outlet for engineering talent may not continue with the same rate of increase, but there are new openings for engineers which are constantly coming forward, and which lead me to believe that the prosperity of the profession will long continue. Already various branches which have hitherto been included in civil engineering, that is, mining and metallurgical work, mechanical work, electrical work, etc., have grown so fast that they have warranted and required the organization of large and prosperous societies. There are I think new openings for civil engineers, probably in the irrigation and drainage works, and it is a curious fact that a little over one hundred years ago, there were no civil engineers in Great Britain and when they began the reclaiming of their waste lands, and the drainage of their fens, they had to import engineers from Holland in order to show them how to do it. We fortunately, in this country, have already a good start in that direction and I expect that class of work to take a large expansion. There are besides, the improvement of our navigable waters, the conservation of our national resources which has lately attracted great atten-

tion, and which in my judgment will require a great deal of work from the engineers. But above all, the one thing for which I am most particularly grateful, is that thus far instances of dishonesty and graft have been very rare amongst engineers. The profession has maintained a high standard both of scientific attainment and integrity and I feel sure that all of you gentlemen will do your utmost to maintain and increase that standing.

I thank you very much for the honor you have conferred upon me.

President Loweth: Forty years ago and a little more, the first bridge across the Missouri River was completed; I refer to the bridge at Kansas City now used by the Chicago, Burlington and Quincy Railroad. That bridge is in use today and giving good service. It was at that time, and for many years afterward, a very notable achievement in civil engineering, Mr. Chanute was chief engineer of that bridge, the first bridge built over the Missouri River. It seems a happy coincidence tonight that chance has brought Mr. Chanute and General Dodge side by side at this table. General Dodge was engineer of the Union Pacific Railroad about the time that Mr. Chanute began the Kansas City Bridge, and he began the work of building a bridge over the Missouri River between Council Bluffs and Omaha; he began his bridge a few months before Mr. Chanute began his, but encountered legal difficulties which caused his work to be abandoned temporarily, and so his bridge was not completed until soon after the Kansas City bridge, and was the second bridge over the Missouri River.

Mr. Chanute was, for many years, as you probably all know, the Chief Engineer of the Erie Railroad. We think that this is the beginning of the age of concrete. I remember perhaps twenty-five years ago, that Mr. Chanute read a paper before the American Society of Civil Engineers, in which he described some work he had been doing on the Erie Railroad in which he had made an extensive use of concrete in strengthening old bridge substructures, so that he was one of the pioneers in the use of concrete which is so generally used today. I am very sure that this society has honored itself in electing Mr. Chanute an honorary member.

Now, gentlemen, the constitution of our society provides that the newly elected officers shall enter upon the discharge of their duties immediately upon notification of their election. It is my pleasure to inform you that Mr. Andrews Allen has been elected president of the Western Society of Engineers, and I have the pleasure of introducing to you Mr. Allen and of tendering him the gavel.

President Allen: Gentlemen of the Western Society of Engineers:

It is hardly fair to expect a newly elected president having had only two hours' notice of his election to make an address to such a body as this. This duty is, however, as Mr. Loweth has said, imposed on him whether he will accept it or not. I have no choice, so I will make my address very short.

I am deeply sensible of the honor that you have bestowed upon me, especially as I am following such a long line of able and illustrious men who have occupied this chair. I have always been a worker in the ranks of this society and shall continue to be. The thing that the society needs to make it a success is a loyal and active membership. Its officers can do very little but guide and direct; the motive power has to come from within. As I look at the year that is to come my feeling is one of great responsibility, and my hope in assuming this office is only that I may be able to give as good an account of my stewardship as the president who is just retiring.

We have a very interesting program this evening and have been honored by the presence of some most distinguished guests.

It is fitting in this age of rapid construction and exploitation to sometimes look back at the work that has been done by the older civilizations. We are a young people; the things that we have accomplished in America in the short time since its discovery and settlement are phenomenal, almost magical, if looked at from the standards of the old world. It does us good occasionally to get back and see what the other civilizations have accomplished, both those which have flourished and passed away and those which remain either in their strength or in their decadence. The address that is to follow will bring to

our notice the engineering works of the great empires of China and Japan, the first representing perhaps a decadent, at least a stagnant civilization, the other having newly come to a sense of its power and awakened into a world-wide position.

Mr. Bates needs no introduction from me. He has served as president of this society and been one of its honored members for a great many years. He was formerly engaged in railroad engineering, and for years pursued an even career in that work. He finally left the railroad service and went to contracting, and it only took him a few years to retire and go abroad. He comes back to us with the wealth of information gathered there, enriched by his own experience in a most varied engineering service, and I take pleasure in introducing Mr. Onward Bates.

Mr. Onward Bates: Mr. President and fellow members of the Western Society of Engineers, and our invited guests:

This is truly a happy meeting. In my experience I have never known such a good presidential address as that of our latest past-president, the one we listened to. Never has this society, it appears, been in as good a condition, so well housed, with so much money in the bank and such—I was going to say such a good lot of fellows, but I will say such a great lot of good fellows, as at the present time. This is a happy occasion indeed, and I envied him tonight when he made that address and I thought of the past.

I have seen the time, gentlemen, when a select committee would come to my office and because I had not attended a meeting would make me pay for it, and then when they got their pay they seemed so well pleased that I rather imagined they were glad I stayed away from the meeting.

I wish to add a word about our friend Mr. Chanute. It made me happy to hear this petition read and to know that he has been made an honorary member, because it is the society that is honored, Mr. Chanute has been an inspiration to young engineers. When I was a boy I enjoyed the friendship of Captain Eads who built the St. Louis bridge, and I helped him build it. My name does not go down to history in that connection, but I remember in his office there was a framed picture of Mr. Chanute who had just recently completed the Kansas City bridge which has been mentioned this evening, and I have heard praise from Captain Eads, who considered Mr. Chanute at that time, forty years ago, one of our great engineers. The career of such men as Chanute, Eads, and Shaler Smith, has been a great inspiration to me. So that I rejoice in this honor which has been accorded him by our society.

A few days ago our latest past-president asked me if I would not address this meeting. After coquetting a little I agreed; of course I was going to agree anyhow: anything that is put at me, I take in an engineering line. Then I asked him, "What shall I talk about?" "Why," he said, "about your trip abroad." That sounds very well, "abroad," so I agreed to that. I said, "How much of a talk do you want?" He said, "Ten minutes," and then he thought a little bit and said, "Fifteen minutes maybe." Well, you know, he had already given me my credentials when I went away. I carried a passport signed by Mr. Root, you have all heard of Elihu Root! and I had a certificate signed by the President and Secretary of the Western Society of Engineers, stating that I was a member, so I was well heeled when I went into these foreign parts.

But how am I to tell all about a six months' trip in ten minutes or fifteen minutes or something of that sort? Why, I couldn't get as far as Seattle in that time. I will tell you what I think I am going to do now; it is twenty minutes to ten, and I want you to hear these other gentlemen, particularly General Dodge and Mr. Trumbull, on those interesting subjects. Anything that I can say about engineering in China and Japan can be just as well said at some other time, and if I may be excused from embarking on a subject that I ought to have ten hours for, I would like to have it put off, because we have not more than time enough to allow these other gentlemen to address us on subjects that we cannot hear talked of again. I think the president will excuse me, and if he will I will agree to talk to you in one of the regular meetings this winter.

President Allen: I regret very much that I shall have to excuse Mr. Bates as he has already seated himself. I would not do so otherwise, I can assure him. But even if he has not spoken on Engineering in China and Japan, tonight, we will make that a special order for some future occasion. We are sure to have it one of these days. I know that he will be very glad to speak to us on that topic.

Mr. Bates: I will agree to do that.

President Allen: Our next address was to have been "The Inland Waterway," by Mr. E. S. Conway. Unfortunately Mr. Conway has been called away from the city, and one of our guests has very kindly consented to take his place on the program. I do not know if I am giving away secrets in mentioning a little incident in this connection, but the chairman of the entertainment committee is a very good bargainer apparently, and a contract is a contract as I know. So I will make bold to say that when Mr. Morris Trumbull offered Mr. Houghteling a seat at the table beside Mr. Frank Trumbull, he attached to it a promise that in consideration thereof Mr. Houghteling would consent to speak. I am advised that the party of the first part has fulfilled its part of the contract. I now call upon the party of the second part, Mr. Houghteling.

Mr. James Houghteling: *Mr. President and members of the chosen people of the Western Engineers:*

I want first to apologize for my presence here and for that of the few other Gentiles whom I see among you. I suppose Mr. Fred Delano considers that he has some sort of right to be here; he is only a railroad president but I believe he did do something in a rule of thumb way in mechanical engineering when he got out of Harvard College; but he has forgotten it and I really don't know why he is here. But it is very consoling all the same.

This man at my right, Mr. Frank Trumbull, is nothing but an ex-railroad president; but he can talk. I don't know why the engineers should have to get outside speakers in here, from the samples I have had so far of what they can do themselves.

I must say that I smiled a little when the president said that I kindly consented to speak. I was taken by the throat! I was invited here to eat and to listen and then they proceeded straight away, upon my acceptance yesterday, to bribe me. That is a new sensation; I am on the other side of the transaction, and I am afraid that it is a bad bargain all the way around, and that we can all say what the man said who, in the early days, went over from Baltimore to the Western Reserve to buy hogs, and he bought them and drove them afoot across the Allegheny mountains and the market went down and he sold them in Baltimore for just what he paid for them in Ohio. He said, "Anyhow I had the company of the hogs for six weeks."

I am not going to take any great amount of time with any feeble talk that banker folk or other Gentiles can give in this company. I thought I would revive for a minute or two some recollections of engineers that I have known, and as I thought the matter over this afternoon it was impressed upon me that we do not love men for their achievements. There was a very distinguished gentleman, General Francis A. Walker, president of the "Tech," some of you men know him, and every man who ever knew General Walker loved him, and we loved him at the Sheffield Scientific School where he was a professor. We did not love him because he was the most perfect gentleman that ever sat in a professor's chair. He called the roll with a "Mister" in front of every man's name; he never saw or attempted to see or dreamed that anything went on behind the benches, that there was any "skinning" or "cribbing" or anything of that kind, and there was not. We played the game fair with him. He was so high-toned a gentleman that no man could without shame, no matter how hardened he was, do an ungentlemanly act in his presence. He was a great scholar, he was a distinguished soldier, but we did not love him for these things. Why do you suppose we loved him? Well I told the boys at a "Tech" dinner a few years ago why. General Walker was loved by us because of the legend there was in the school that when he was a young man he killed a man with a billiard cue. That is the reason we loved him. And

so you cannot tell exactly why you love men, but it is not on account of their achievements.

And so as I think of old Julian Kennedy, who builds blast furnaces; I believe he is somewhat known in the engineering profession, especially among the mechanical men as being quite an engineer. He was a fine scholar, he was a very big man, he was a man as Mulvaney says, who had hands and feet both of the same size, number twelve; but we loved him because he licked Harvard on the eight and in the single sculls.

There was that great mining engineer, John Hays Hammond, who has done some very wonderful things in the profession, some people say he stands at the top of the profession. I remember how he used to come around to the other fellows' rooms with a trigonometry or something hugged up against his side as if there was a sort of exosmosis and endosmosis effect going on by which he actually acquired learning, and say "Well fellows how are you getting along?" and it was that genial fellowship of the man, that sympathy, that boyishness which he has never gotten over, those qualities which made him the prince of good fellows, which made him then and since loved among his fellow men.

But we need not go far afield to illustrate these things: there is our own Isham Randolph, Sir Galahad, the gentleman of the old school. It is not necessary, for him to win our love, to be the head of our own great engineering problem here, or that he should be chosen by Mr. Taft to go to Panama to tell them whether they are going to hold that dam or not. He lives with us because of the qualities of heart, and those qualities that make a man, the brains, and honesty, and perseverance, and courage and self-sacrifice which are the factors of true manhood. The kind of manhood that you find mighty often in the company of the engineers.

President Allen: The next address is on "The Railroad Situation of Today." This is a very large subject, indeed, and suggests not only the railroad situation of the past, the era of exploitation and promotion, but the present turmoil in the railroad world, with the railroads on the defensive and the States and the Government making all sorts of restrictions and attempts at regulation. It also suggests what will ultimately come out of this crucible into which the materials have been thrown. This is the problem of the present for results in the future.

Mr. Trumbull like many, I might say most, of the great railroad men of this country, is a self-made man in all that that word implies. He started at the age of fourteen in a general store, and has worked from position to position until at the present time he occupies the position of president of the Colorado & Southern R. R. System and the head of that reorganization of which he was formerly receiver. Mr. Trumbull comes to us with full knowledge from an active life spent—hardly that, because he has many active days before him—spent so far in railroading, and I take great pleasure in introducing, as I know the society will take great pleasure, in hearing, Mr. Trumbull, and in calling upon him to speak on "The Railroad Situation of Today."

(Mr. Trumbull's address is printed elsewhere in this issue of the Journal.—Ed.)

President Allen: Gentlemen, the railroad business is the greatest industry of this country, and in that sense justifies its importance on this program. We will all welcome the day when the spirit of co-operation and friendship on the one hand and stewardship on the other shall have taken the place of the present, and the past, era of competition and rivalry, a relic, as it seems to me, of the stone age, when the man who had a difference with his neighbor went after him with a club. We have seen some recent examples and that in high places, but in the end the club must go and it must be the spirit of friendly help on the one hand and stewardship upon the other as Mr. Trumbull has so eloquently said.

Now it is my pleasure to pass to the concluding address of this evening, "The Engineers' Work in the West at an Early Day and during the Civil War," by General Grenville M. Dodge. Mr. Dodge needs no elaborate introduction from me. He came west in 1850 as ax-man on the Illinois Central

Railroad. His career since that time has been intimately connected with the development of the country. There is probably no man in the country today that has grown up with the railroads, been a part of their development and formation as intimately as General Dodge has. During the war he laid aside his duties as an engineer and fought for his country until peace was declared. He made the original reconnoissance of the Union Pacific road at a time when the engineering party had to be guarded by a squadron of cavalry. And, after that, when the building of the Union Pacific was decided upon, he was sent for by President Lincoln to confer as to the starting point of the enterprise.

Since that time he has probably built more miles of road than any other man in the world. I might take up your time in enumerating the different positions that he has held and the different roads that he has built, but I feel you would very much rather hear from him than hear as elaborate a description as could be given of his life work. Therefore, I take great pleasure in calling upon General Grenville M. Dodge to address you.

General Grenville M. Dodge: Mr. President and comrades of the Western Society of Engineers:

It is a great pleasure and a great satisfaction to me to have the opportunity to meet you. You probably will be greatly astounded to know that you are the first body of engineers that I have ever met in my life. I came here so I could say that I had seen a body of civil engineers, and I wish to say to you that I take great pleasure and great satisfaction in being here when you paid the honor you have to my old friend here, Mr. Chanute. I would have come all the way from my home here to have witnessed that if for nothing else and I thank you for it.

What I have to say I have condensed as much as I can and will read it to you.

(General Dodge's address is printed as the initial paper in this issue of our Journal.—Ed.)

President Allen: Gentlemen, nothing that I could say would be adequate to express to General Dodge our profound appreciation of the pleasure he has given us this evening. This has been a memorable occasion and I am sure every one of us will look back at this evening as long as we live. General Dodge, allow me on behalf of the Western Society of Engineers to tender you our heartfelt thanks for your address to us this evening. The meeting then adjourned.

ELECTRICAL SECTION, JANUARY 15, 1909.

A regular meeting (No. 38) of the Electrical Section (being No. 649 of the Society), was held Friday evening, January 15, 1909.

The meeting was called to order about 8:20 P. M., by Chairman D. W. Roper.

The secretary announced that this was the annual meeting of the Section, when the officers for the year 1909 were to be elected. As there was but one ticket in nomination presented by petition at the meeting in December, the motion was made and carried that the vote of the Section be cast by the secretary. This was done with the result as follows:

Chairman to serve one year, Wm. B. Jackson; vice chairman to serve one year, P. B. Woodworth; member of the Executive Committee to serve three years, W. L. Abbott; hold-over members of the Executive Committee, K. B. Miller to serve one year, and E. N. Lake to serve two years.

In the absence of Mr. Wm. B. Jackson, Prof. P. B. Woodworth took the chair, making a short address. He then introduced Prof. C. F. Burgess, of Madison, Wisconsin, who addressed the meeting on "Corrosion in Steam Boilers as an Electrochemical Phenomena." This was illustrated with a number of lantern slide views.

Discussion followed from Messrs. P. B. Woodworth, W. L. Abbott, D. W. Roper, C. Kemble Baldwin, R. F. Schuchardt, and J. L. Hecht.

The meeting adjourned about 10:15 P. M.

February, 1909

EXTRA MEETING, JANUARY 20, 1909.

An extra meeting of the Society (No. 650) was held Wednesday evening, January 20, 1909.

The meeting was called to order about 8:20 P. M., with President Allen in the chair, and about 75 members and guests present.

There was no business to bring before the meeting, but an explanation was made and apology offered for the unavoidable absence of Mr. R. P. Lamont, M.W.S.E., and of James C. Davis, his associate in the American Steel Foundries Co., the author of the paper for the evening on "Steel Castings." The paper was read by the secretary, after which lantern slide illustrations were shown of some notable examples of steel castings.

Discussion followed from President Allen and Messrs. James C. Hallsted, E. N. Layfield, J. H. Warder, Wm. Sooy Smith, Ernest McCullough, B. A. Gayman, M. Rilly, B. B. Carter, J. C. Bley, W. E. Symons, W. V. Young, and Chas. K. Mohler.

The meeting adjourned about 10:20 P. M.

REGULAR MEETING, FEBRUARY 3, 1909.

A regular meeting of the Society (No. 651) was held Wednesday evening, February 3, 1909.

The meeting was called to order at 8:30 P. M., with President Allen in the chair, and about 70 members and guests present.

The minutes of the meetings of January 5th and 20th, were read and approved.

The secretary reported from the Board of Direction that at their meeting held February 2nd, the following were elected into the Society:

Wilbert M. Richards, Chicago	Junior
George W. Bulley, Chicago	Active
John Hornbrook, Chicago, ...	Transfer from Junior to Active
Maurice L. Carr, Chicago	Active
Albert B. Moore, Chicago	Active
Frederic A. Bergbom, Chicago.....	Transfer from Associate to Active
Frank E. Lamphere, Chicago.....	Transfer from Junior to Active

Also that the following had made application for membership:

Howard Logan, Chicago	Active
Henry B. Sauerman, Chicago.....	Transfer from Junior to Active
Alexander R. Webb, Chicago	Junior
Robert M. Black, Berwind, W. Va.....	Transfer from Junior to Active
Daniel B. Luten, Indianapolis, Ind.....	Active
Paul E. Green, Chicago	Active
Chas. A. Boughman, Marshalltown, Iowa.....	Active
Fred C. Taylor, Chicago.....	Junior

The president then introduced Past President H. E. Horton, who read his paper on "Water Storage in Elevated Tanks and Standpipes," which was illustrated by 26 lantern slide views, showing various designs of elevated tanks and supporting framework.

Discussion followed from Messrs. O. E. Strehlow, T. W. Snow, C. B. Burdick, J. N. Darling, W. W. Curtis, T. L. Condron, C. W. Naylor, W. B. Storey, Jr., M. H. Dance, H. F. White and the author.

Meeting adjourned at 10:05 P. M.

ELECTRICAL SECTION, FEBRUARY 5, 1909.

A regular meeting (No. 39) of the Electrical Section (being No. 652 of the Society), was held Friday evening, February 5, 1909.

The meeting was called to order at 8:15 P. M., by Chairman Wm. B. Jackson, with about 80 members and guests present.

The reading of the minutes of January 15th, was dispensed with.

The chairman introduced Dr. E. H. Lewis, who explained some things about the study and research of the speaker of the evening, and then introduced Prof. Jagadis Chunder Bose, of the Presidency College, Calcutta, India, who addressed the meeting on the "Polarization of Electric Waves." Some interesting and ingenious apparatus was used to illustrate the lecture.

Discussion followed from Prof. P. B. Woodworth and Messrs. W. L. Abbott, Fritz Lubberger, and W. B. Jackson.

The meeting adjourned at 9:40 P. M.

EXTRA MEETING, FEBRUARY 17, 1909.

An extra meeting of the Society (653) was held Wednesday evening, February 17, 1909.

The meeting was called to order about 8:25 P. M., with President Allen in the Chair and about 85 members and guests present. There was no business to bring before the Society, so the President introduced the speaker for the evening, Mr. W. S. Potter, of Paterson, N. J., who presented his paper on "Manganese Steel." There was an exhibit of specimens of this metal, in fractured ingots and castings and in some rolled specimens. Some lantern slide views were exhibited showing samples of plates, bars, etc., twisted and deformed to show the toughness of the metal.

Discussion followed from, President Allen, W. E. Symons, C. L. Strobel, E. H. Lynde, C. K. Mohler, A. C. Smith, and H. S. Bowen.

Meeting adjourned about 10:45 P. M.

EXTRA MEETING FEBRUARY 25, 1909.

An extra meeting of the Society, (No. 654) to which ladies were invited, was held Thursday evening, February 25, 1909.

The meeting was called to order about 8:30 P. M. by President Allen, with about 150 members and guests, including many ladies, present.

Mr. Onward Bates, Past President, was introduced and gave an interesting and instructive talk relating to his recent trip to Japan, China and the Philippines. His talk was illustrated by a large map of the country, projected on the screen.

The meeting adjourned about 9:30, when some simple refreshments were served.

J. H. WARDER,
Secretary

ANNUAL REPORTS

REPORT FROM THE JUDGES OF THE ELECTION.

January 5, 1909.

The undersigned Judges of Election, having canvassed the ballots cast for officers of the Western Society of Engineers for the year 1909, have the honor to report as follows:

Total number of ballots cast	399
Number of ballots rejected as irregular	8
Number rejected as not qualified to vote on account of non-payment of dues	1
	9
Total number of ballots counted	390
Total number of ballots cast for President, Andrews Allen.....	181
J. W. Alvord	135
W. B. Storey, Jr.....	69
Number of votes cast for First Vice President,	
P. Junkersfeld	363
Number of votes cast for Second Vice President,	
O. P. Chamberlain	360
Number of votes cast for Third Vice President,	
W. F. M. Goss	204
W. K. Hatt	68
E. H. Lee	104
Number of votes cast for Treasurer,	
Albert Reichmann	369
Number of votes cast for Trustee for three years,	
G. M. Brill	223
Ernest McCullough	141

(Signed) H. M. MORSE.
ERNEST F. SMITH.
W. BIRCH-NORD.

SECRETARY'S REPORT.

To the Board of Direction, Western Society of Engineers, Chicago.

GENTLEMEN: Of the affairs of the Western Society of Engineers, I have the honor to report as follows:

The membership of the Society has not materially changed since January 1, 1908. There were 54 applications during the year acted upon, of which 10 were transfers from Junior grade; and 8 were applications filed in 1907, of which one was a transfer from Junior. Additions of new members, 49; less 2 who did not qualify, or 47 net. There were 5 deaths, 26 resignations, and 23 dropped for non-payment of dues.

Past-President O. Chanute has been transferred to the Honorary grade.

The membership now stands:

Honorary members	2
Active members, resident.....	440
Active members, non-resident	343
	783
Associate members, resident	57
Associate members, non-resident	10
	67
Juniors, resident	99
Juniors, non-resident	42
	141
Total membership	993

This lack of growth was to be expected, considering the conditions of business for the past year.

The five deaths among our active members were:

James Dun, February 23, 1908.

Chas. H. Tutton, June 19, 1908.

E. H. Beckler, August 26, 1908.

Chas. A. Smith, October 20, 1908.

Ossian Guthrie, October 25, 1908.

During the year there were 28 called meetings, including those of the

Electrical Section, as follows:

1 Annual Meeting.

9 Regular Meetings, on the first Wednesday of each month except January, July and August.

8 Extra Meetings.

9 Electrical Section Meetings.

1 Smoker or House-warming, October 29th.

There was also a one-day Excursion to Gary, Indiana, October 8th.

The list of the meetings is as follows:

Tuesday, January 7, 1908:

The 38th Annual Meeting (No. 621 of the Society) was held in the Club Room of the Chicago Athletic Association, followed by a dinner and addresses from retiring President W. L. Abbott, Dr. Edmund J. James, President of the Illinois State University, and others.

Friday, January 10:

Regular and Annual Meeting (No. 29) of the Electrical Section (being No. 622 of the Society). Mr. H. Russell Smith (on behalf of Mr. John D. Ihlder of New York) presented a paper on "*Electric Elevators for High Buildings.*"

Wednesday, January 22:

Extra Meeting (No. 623). Topical Discussion by Messrs. W. C. Armstrong, F. H. Bainbridge, Andrews Allen, H. E. Horton, A. Reichmann and President Loweth, "*The Wrought Compressive Member for Bridge Trusses.*"

Wednesday, February 5:

Regular Meeting (No. 624). Professor H. B. MacFarland presented his paper on a "*Test of a Small Suction Gas Producer Plant.*"

Friday, February 14:

Regular Meeting (No. 30) of the Electrical Section (No. 625 of the Society). Mr. James N. Hatch, presented his paper on "*The Evolution of the Electric Railway.*"

Wednesday, February 19:

Extra Meeting (No. 626). Mr. Wilson E. Symons presented his paper on "*The Passing of the Steam Locomotive.*"

Wednesday, March 4:

Regular Meeting (No. 627). Mr. Geo. M. Brill presented his paper on "*Location, Arrangement and Construction of Manufacturing Plants.*"

Wednesday, March 11:

Regular Meeting (No. 31) of Electrical Section, (No. 628 of the Society). Prof. Morgan Brooks addressed the meeting on "*The Operation of Alternators in Parallel.*"

Wednesday March 25:

Extra Meeting (No. 629). Mr. J. N. Darling read his paper on "*Some Features of Construction of the South Side Elevated Railway.*"

February, 1909

Wednesday, April 1:

Regular Meeting (No. 630). Mr. Wm. M. Torrance read his paper on "*Reinforced Concrete Structures in the Hudson River Tunnel Work.*"

Friday, April 10:

Regular Meeting (No. 32) of the Electrical Section, (No. 631 of the Society). Mr. J. C. Kelsey read his paper on "*The Relation between the Banker and the Engineer.*"

Wednesday, April 15:

Extra Meeting (No. 632). Professor A. N. Talbot presented his paper on "*Tests on Cast Iron and Reinforced Concrete Culvert Pipe.*"

Wednesday, May 6:

Regular Meeting (No. 633) Professor J. C. Thorpe presented his paper on "*Steam Turbine Development.*"

Friday, May 8:

Regular Meeting (No. 33) of the Electrical Section (No. 634 of the Society). Mr. F. R. Babcock addressed the meeting on "*The Electrical Equipment of Steam and Gasoline Automobiles.*"

Monday, May 18:

Extra Meeting (No. 635). Dr. P. H. Dudley read his paper on "*Steel Rails for present service; their Manufacture and their Failures.*"

Wednesday, June 3:

Regular Meeting (No. 636). Mr. E. M. Griffith, Wisconsin State Forester, addressed the Meeting on "*The Conservation of the Forests and Water Powers of Wisconsin.*"

Wednesday, September 2:

Regular Meeting (No. 637). Mr. H. von Schon read his paper on "*The Analysis of an Hydro-Electric Project.*"

Friday, September 25:

Regular Meeting (No. 34) of the Electrical Section (No. 638 of the Society). Mr. F. A. Sager presented some "*Notes on the St. Clair Tunnel Electrification.*"

Wednesday, October 7:

Regular Meeting (No. 639). Mr. L. R. Stowe presented his paper on "*Methods of Studying the Heat Absorbing Properties of Steam Boilers.*"

Friday, October 16:

Regular Meeting (No. 35) of the Electrical Section (No. 640 of the Society). Mr. H. B. Gear presented his paper on "*The Development of an Alternating Current Distributing System.*"

Wednesday, October 21:

Extra Meeting (No. 641). Mr. A. N. Johnson presented (in abstract) his paper, "*Specifications and Notes on Macadam Road Construction.*"

Wednesday, November 4:

Regular Meeting (No. 642). Col. C. McD. Townsend presented his paper on "*The Improvement of the Upper Mississippi River between St. Paul and St. Louis—The Work of the National Government.*"

Friday, November 13:

Regular Meeting (No. 36) of the Electrical Section (No. 643 of the Society). Mr. W. D'A. Ryan addressed the Meeting on "*Recent Development in Artificial Illumination.*"

Wednesday, November 18:

Extra Meeting (No. 644). Mr. Carl Scholz addressed the Meeting on "*Coal Briquetting.*"

Wednesday, December 2:

Regular Meeting (No. 645). Mr. H. H. Evans addressed the Meeting on "*Development in Electrification of Railway Terminals.*"

Friday, December 11:

Regular Meeting (No. 37) of Electrical Section (No. 646 of the Society). Further Discussion of the subject, "*Electrification of Railway Terminals,*" by Messrs. Roper, Storey, Symons, Abbott, Camp and Evans.

Wednesday, December 16:

Extra Meeting (No. 647). Professor W. D. Pence presented his paper on "*The Work of the Engineering Staff of the Wisconsin Tax and Rate Commissions.*"

During the past summer extensive enlargement and changes have been made in our quarters on the seventeenth floor of the Monadnock Block. The increase in space takes in the full width of the building with windows on both sides, thereby securing light and air from both east and west. The space secured from the agents of the building measures a little over thirty-eight hundred (3800) square feet, and a new lease for a term of ten (10) years was taken at a rental of \$2,500.00 per year. The original corridor walls were taken out and new partitions put up about a central portion for an assembly room which is 36 feet wide by 44 feet long, with a seating capacity of about 170. The library is along the east wall, and along the west wall are two smaller rooms, one for the use of committees, the Board of Direction, etc., and the other a work and store room. The reading room, at the right of the entrance, is the space formerly used for the same purpose, while the accommodations for the secretary and his assistants are at the left of the entrance. The entrance from the corridor, with wide double doors having plate glass panels, opens into a pleasant reception space, which, however, is not separated by any partitions from the reading room or secretary's office to the right and left respectively. A glass ceiling overhead gives plenty of daylight from a large sky-light of the building. The usefulness and attractiveness of the new quarters is shown by the increase in the number of visitors and the greater use made of the library and reading room.

Very respectfully submitted,

J. H. WARDER,
Secretary.

LIBRARIAN'S REPORT.

To the Board of Direction, Western Society of Engineers, Chicago, Ill.

GENTLEMEN: The librarian begs to submit the following as his report on the library of the Society.

Number of books accessioned up to December 31, 1908.....	6,957
Number of books accessioned up to December 31, 1907.....	6,583
Additions to the library during 1908.....	374

These may be classified as follows:

Number of volumes of serials bound by the Society.....	77
Number of bound books, (gifts and exchanges).....	172
Number of volumes bought by the Society.....	51
Number of pamphlets accessioned.....	74

The total charge against the library for 1908 is.....	\$492.46
Less sundry returns to the library account.....	22.50

Net charge against the library \$469.96

February, 1909

Classified as follows:

Services	\$271.70
Books purchased	112.21
Binding of books.....	78.45
Sundries	7.60

Total\$469.96

Account for furniture and fixtures for 1908.....\$508.65

Total\$978.61

Very respectfully submitted,

J. H. WARDER,
Librarian.

TREASURER'S REPORT FOR THE YEAR ENDING DECEMBER 31st, 1908.

January 2nd, 1909.

To the Board of Direction, Western Society of Engineers, Chicago, Ill.

GENTLEMEN: I respectfully submit herewith, a statement of the Treasurer's account for the year ending December 31st, 1908, as follows:

CASH STATEMENT.

January 1, 1908, cash in bank subject to check..... \$844.29

RECEIPTS.

Dues	\$10,447.58	
Entrance Fees	650.00	
Subscription to Journal.....	351.09	
Advertising	2,796.64	
Sales Journal	157.45	
Interest	639.65	
Library account	22.50	
House expense	153.60	
Sta. Postage and Exchange.....	41.38	
General Printing	245.90	
Furniture and Fixtures.....	25.00	
Chanute Medal Fund Account.....	25.00	
Investments	2,000.00	
J. H. Warder	10.00	
Colo. Trust & Savings Bank.....	1,586.67	\$19,152.46
		<u>\$19,996.75</u>

EXPENDITURES.

Journal Account	\$4,203.93	
Library Account	492.46	
House Expense	3,503.66	
Sta. Postage and Exchange	634.51	
General Printing	936.90	
Furniture and Fixture Acct.....	105.20	
Advertising	143.25	
Insurance Account	117.00	
New Quarters Acct.....	6,580.32	
Entrance Fees	10.00	
Medal Account	50.00	
Services	1,775.00	\$18,552.23
Dec. 31st, 1908, cash in bank subject to check.....		1,188.77
Dec. 31st, 1908, cash on hand.....		255.75
		<u>\$19,996.75</u>

SUMMARY.

Statement Jan. 1st, 1908.

To credit Western Society of Engineers.....	\$ 9,878.09
Chanute Medal Fund.....	1,174.00
Arnold Fund	1,000.00
	\$12,052.09

Investments	11,207.80
Cash	844.29
	\$12,052.09

Statement Jan. 1st, 1909.

To credit Western Society of Engineers.....	\$ 6,853.32
Chanute Medal Fund.....	1,199.00
Arnold Fund	1,000.00
	\$ 9,052.32

Investments	9,207.80
Cash	1,444.52
	\$10,652.32

Col. Trust & Savings Bank loan.....	1,600.00
	\$ 9,052.32

Respectfully yours,
(Signed) ALBERT REICHMANN,
Treasurer.

BOOK REVIEWS

A GUIDE TO TECHNICAL WRITING. By T. A. Rickard, the Mining and Scientific Press, San Francisco, California, 1908. Cloth, 5½ by 8 ins. Price, \$1.00.

This is an admirable book, containing so much good advice to writers generally, particularly those interested in technical matters, that any one concerned with the publication of such papers wishes the little book could be placed in the hands of the great multitude of present-day writers, if they would only read and profit by the instructions contained therein.

The publishers of the book, "The Mining and Scientific Press" of San Francisco, have been established many years, and the high character of the writings of that technical paper bears testimony to the ability of the author of this book to write good, plain, clear English, and on technical subjects. The instructions as to the use of abbreviations, numbers, and hyphens are good and are illustrated with examples and explanations, making the rules more easily remembered. All through the book are many delicious little touches of humor that enliven the matter and tempt to further reading. One chapter on the use and abuse of the word "very," with a few other "unconsidered trifles," and another, "Concerning Titles," are worth the price of the book. There are many other good points in the book and the observation of the hints therein contained, will result in the use and printing of better English by our technical men.

Finally,

"Have something to say, then say it."

"Avoid the use of words the meaning of which is doubtful to you."

"Make your meaning clear; then consider style, but sacrifice elegance, even modesty, to directness of statement."

Above all things, *Remember the Reader.*

February, 1909

ELECTRICAL ENGINEERS' POCKET BOOK, of useful Data for Electricians and Electrical Engineers. By Horaito A. Foster, with the collaboration of eminent specialists. 5th edition, completely revised and enlarged. 4¼ by 7 ins. 1636 pages, many tables, diagrams and illustrations. Extensive index and thumb index. Leather bound. Full gilt. Price, \$5.00. D. Van Nostrand & Co., New York, 1908.

The fifth edition of this useful book shows quite an improvement over previous volumes; in other words, it seems to have kept pace with the rapid advance in the art since the earlier editions. The new book is about half again as voluminous as the fourth edition, showing the addition of a large mass of new matter.

In a few matters the improvement given appears too limited, as for instance in regard to data for cooling electrical apparatus. Air cooled apparatus forms a large part of central station installations and data regarding same would be of value. Unit weights of apparatus used in electrical installations appear to be missing.

With a few exceptions of this kind the book is fairly complete and much thought and labor has evidently been spent on that most important section, the index, thus adding very materially to the usefulness of the volume. It should find a place on every engineer's desk.

C. A. K.

LABORATORY NOTES ON INDUSTRIAL WATER ANALYSIS. A Survey Course for Engineers. By Ellen H. Richards, Instructor, Mass. Inst. Tech. New York, John Wiley & Sons. 1908. Cloth, 6 by 9 ins.; pp. 48. Price, 50 cents.

This is a desirable book for engineers who have a little working knowledge of chemistry and are interested in the subject of water supply for industrial or domestic use, with but limited experience in analytical chemistry, and the use of this little book. At least preliminary investigation can be made of an unknown water, to decide whether it should be investigated further or abandoned in favor of some other supply. It is not a book to be of much service to trained analytical chemists, but should be of considerable value to engineers as above noted. The scale producing constituents of natural waters, by their almost universal presence to a greater or less degree, are of much interest to those concerned with steam power generation, as well as some other industrial pursuits. Accordingly the author gives a simple classification of three divisions, under which industrial waters may be first examined and rated. Subsequent exercises and explanations will enable the engineer to arrive at a fair conclusion as to whether the water can be used as it is, or whether it can be modified (softened or neutralized) within a reasonable cost, and thus make it available.

At the end of the book is a page giving "Some Useful References," or a partial bibliography of the subject that is of interest to those concerned in the question of Water Supply.

W.

THEORY AND DESIGN OF REINFORCED CONCRETE ARCHES. A treatise for engineers and technical students. By Arvid Reuterdaahl, Sc. B.A.M., Chief of Bridge Department, Engineering Department, City of Spokane, Washington. (Formerly Instructor of Mathematics at Brown University and Professor of Physics at Colby College.) Chicago, The Myron C. Clark Publishing Co. Cloth, 6 by 9 ins.; pp. 124. Price, \$2.00.

This book is a timely treatise on an old but important branch of engineering. The author has had under his charge the design and erection of several important reinforced concrete arches for the City of Spokane, and with his experiences as a teacher in mathematics should be qualified to write (as he states in the preface) a book for the practical engineer.

The effort of the author is to demonstrate fully and supply the missing steps in "works which have heretofore appeared on this subject which are so mathematically abstruse or leave so much to the reader to demonstrate for himself." The subject is treated in three chapters: First, Theory of the Elastic Arch; second, Design of a Reinforced Concrete Arch; and third,

Calculation of Fibre Stresses, with Appendix A. and B. The arch fixed at the ends, with no hinges, is the only one discussed.

In Chapter 1, the author starts directly in to develop the forces of the Elastic Arch without preliminary discussion or introduction. In the middle of the chapter he develops the theory of the equilibrium polygon and explains its use. Then a full discussion of temperature effects completes the chapter. There is much of interest which could have been said in a few pages on the Historic Development of the Arch theory; especially a brief definition of the "Elastic Theory" and its peculiar fitness to the reinforced concrete arch over that of the masonry or stone arch, would not have been out of place. The author in this chapter follows somewhat closely the well known work of William Cain.

In Chapter 2, we have the Loading for Railway and Highway Bridges; two formulae for determining the crown thickness for trial arch; proportioning the backing; amount of steel reinforcing, and properties of concrete and steel briefly discussed. Conditions for calculations and the design of a seventy foot span, fifteen feet rise, arch for highway bridge are carried out with complete detail. A comparison of the two (Well's and Luton's) trial crown thickness formulae with the many others proposed by different authors and also with the actual crown thickness of many arches already built would have been of interest to most engineers and of value to many. It is to be regretted that there is not a more complete set of tables giving important dimensions of arches in service, the tables in "Howe's Symmetrical Masonry Arches" being the most complete in the reviewer's knowledge.

Under the "properties of concrete" the reviewer would be inclined to criticise the author's method of giving the modulus of elasticity of "Burnt Clay Concrete = 1,500,000" and of "all other concrete = 2,000,000" as inaccurate in statement.

Under "Properties of Steel" it is the reviewer's opinion that authorities agree in basing the factor of safety for the steel element in the composite structure upon the elastic limit of the steel rather than upon the ultimate strength as does the author. Also it appears slightly incorrect to use the ratio $n = 20$ when the maximum compression allowed in the concrete at 600 lb. per sq. in. as 15 would be more nearly a correct ratio.

The author's method of dividing the arch ring so as to make $s \div I$ constant could be slightly abbreviated by using the method of Turneure and Maurer in their book "Principles of Reinforced Concrete Construction." The last chapter—Calculation of Fibre Stresses—is complete in tables and detail calculations with a bibliography. It appears that in treating the temperature stresses something should have been said about the natural shrinkage of the concrete in setting, which, if the arch is built, (as many small arches are built) in longitudinal strips over the full arch, will give rise to stresses equivalent to that of a greater range in temperature than allowed by the author. These shrinkage stresses may be provided for, however, by a different method of construction, which might have been mentioned.

Appendix A is a copy of the specifications of the Concrete Steel Engineering Company, New York. Appendix B is also a copy of a recent addition to the building code of St. Louis covering concrete work.

On the whole, however, everything about the book appears carefully and well done, although the author, in his attempt to simplify and make plain, has inserted steps and repeated equations so that the book at first sight would doubtless look forbidding to a practical engineer. Most engineers are called upon but occasionally to design arches, and in the interval they are apt to forget much of the procedure, and such a book as the above to refresh their minds and keep them in the straight and narrow way of rectitude, saves many times the value of the book in mental worry lest they jump the rails at some critical point, and this book is admirably fitted for such a purpose.

W. A. H.

LIBRARY NOTES.

The Library Committee wishes to express thanks for donations to the library. Back numbers of periodicals are desirable for the change and in completing valuable volumes for our files.

Since the issue of the JOURNAL for December, 1908, we have the pleasure to report the following additions to the library and gifts from donors named:

MISCELLANEOUS GIFTS.

- Commercial Club, Chicago—
 "Plan for a Boulevard to connect the North and South Sides
 of the River on Michigan Ave. and Pine Street." Pam.
- Worcester Polytechnic Institute, Worcester, Mass.—
 "39th Annual Catalogue. 1908-09." Pam.
- Auditor of State of Ohio, Columbus, Ohio—
 "Comparative Statistics of State of Ohio." 1907. Pam.
- D. Van Nostrand & Co., New York—
 "Electrical Engineers' Pocket Book." Foster. Leather.
- J. Frank Foster, Chicago—
 "Report of the South Park Commission from December 1,
 1906 to February 29, 1908, inclusive." Pam.
- John Wiley & Sons, New York—
 "Laboratory Notes on Industrial Water Analysis." Richards.
- L. Bush, M.W.S.E., New York—
 "Bush Train Shed, Lackawana Railway Terminal, Hoboken,
 N. J." Pam.
- Massachusetts Institute of Technology, Boston—
 "Catalogue, December 1908." Pam.
- Armour Institute, Chicago—
 "Bulletin, Vol. II, No. I."
- Public Service Commission, New York—
 "Reports Adopted December 11th and 18th, 1908." 2 Pams.
- Board of Railroad Commissioners, Iowa—
 "30th Annual Report, 1907." Cloth.
- Department of Mines, Canada—
 "Explorations in Nova Scotia, 1907."
 "Geology and Mineral Resources in New Brunswick." 2 Pams.
- Mining and Scientific Press, San Francisco—
 "A Guide to Technical Writing." T. A. Rickard. Cloth.
- Purdue University, Lafayette, Ind.—
 "Annual Catalogue, 1907-08." Pam.
- John Wiley & Sons, New York—
 "Hydraulic Tables." Williams & Hazen, 2nd edition 1907.
- William H. Burr, New York—
 "Report on Design and Construction of Queensboro Bridge,"
 with chart and drawings. Paper.
- Macmillan Co., New York—
 "Artificial Waterways and Commercial Development." Hep-
 burn. Cloth.
- R. Modjeski, M.W.S.E.—
 "Royal Commission, Quebec Bridge Inquiry." Vol. II, 1908.
 Cloth.

- Missouri Bureau of Geology of Mines—
 "The Lime and Cement Resources of Missouri." Cloth.
- State Engineer and Surveyor, Albany, N. Y.—
 "Annual Report, 1907."
- N. Clifford Ricker, Urbana, Ill.—
 "6th Biennial Report of Board of Examiners of Architects."
 2 Pams.
- Wisconsin State Forester, Madison—
 "Report for 1907-08." Pam.
- Railroad Commissioners, New Hampshire—
 "64th Annual Report, 1908." Cloth.
- Illinois Highway Commission—
 "Second Annual Report, 1907." Pam.
- Public Service Commission, New York. 2 Pams.
 "Report on Car Fender and Wheel Guard Tests."
 "Report on Traffic of Subway of Interborough R. T. Co."
- E. E. R. Tratman, M.W.S.E., Chicago—
 "Pavement Guarantees, Their Use and Abuse." J. W. Howard.
 Pam.
 "Journal, Railway Signal Association." December, 1908. Pam.
- Connecticut Board of Railroad Commissioners—
 "56th Annual Report." Cloth.

EXCHANGES.

- Canadian Mining Institute, Montreal—
 "Journal of Canadian Mining Institute, 1908." Pam.
- University of Colorado. Boulder, Colo.—
 "Journal of Engineering." 1907-08. Pam.
- Institution of Civil Engineers, London—
 "Minutes and Proceedings," Parts III & IV, 1907-08.
- Institution of Engineers and Shipbuilders in Scotland—
 "Transactions, 51st Session, 1907-08." Cloth.
 "List of Officers and Members as of October, 1908." Pam.
- American Society of Mechanical Engineers, New York—
 "Year Book, 1909." Pam.
- Tonindustrie-Zeitung, Berlin—
 "Tonindustrie Kalander, 1909." 3 Pams.
- American Society for Testing Materials, Philadelphia—
 "Proceedings of the Eleventh Annual Meeting, 1908." Paper.
- University of Montana, Missoula, Mont.—
 "Bulletin Nos. 50, 51, 52." 3 Pams.
- Engineering Association of the South, Nashville, Tenn.—
 "Proceedings, Oct., Nov., December, 1908." Pam.
- Washington University, St. Louis—
 "Public Opinion and the Standard Oil Company." Pam.
- American Railway Engineering and Maintenance of Way Association—
 "Bulletin No. 106, December, 1908." Pam.
- Liverpool Engineering Society, Liverpool—
 "Transactions, 34th Session, 1908."
- Institution of Mechanical Engineers, London—
 "Proceedings, July, 1908." Pam.

GOVERNMENT PUBLICATIONS.

- U. S. Geological Survey, (Dept. of Int.) Pams.
 Production of Petroleum in 1907.
 Production of Quicksilver in 1907.
 Production of Magnesite in 1907.
 Production of Gas, Coke, Tar and Ammonia at Gas Works,
 etc., 1907.
 Production of Platinum in 1907.
 Summary of the Mineral Production of the U. S. in 1907.
 Geological Folios Nos. 151 to 159 incl.
 Bulletins Nos. 347, 351, 369, 362, 349, 357.
 • Water Supply and Irrigation Papers Nos. 219, 220, 222.
 "35 Topographical Atlas Sheets."
 "Bulletins Nos. 362, 363, 366, 352, 353, 354, 355, 358, 359, 365."
 "Production of Lead in 1907."
 "Production of Zinc in 1907."
 "Production of Borax in 1907."
 "Production of Copper in 1907."
 "Production of Gold and Silver in 1907."
 "Production of Gold, Silver, Lead, Zinc and Copper in Western States and Territories in 1907."
 "Production of Natural Gas in 1907."
 "29th Annual Report of Director of the U. S. Geological Survey." Pams.
- Department of Commerce and Labor, Census Office—
 Special Report, "Statistics of Cities having a Population of over 30,000". 1906. Quarto, Cloth.
 Transportation by Water, 1906. Quarto, Cloth.
 "Lumber Cut of the U. S. in 1907". Pams.
 "Special Report, Transportation by Water, 1906." Cloth.
 "Supply and Distribution of Cotton, Year ending August 31, 1908." Pam.
 "Marriage and Divorce, 1887 to 1906." Pam.
 "Express Business in U. S. 1907." Pam.
 "Special Report, Marriage and Divorce, 1867 to 1906," Part II, 1908. Cloth.
- Isthmian Canal Commission, Ancon, C. Z.—
 "Canal Record." Vol. I, September 1907 to August 1908. Cloth.
- Department of Agriculture, Forest Service—
 "Circulars Nos. 158, 150, 155, 156, 159."
- Librarian of Congress—
 "Report of Librarian of Congress for the year ending June 30, 1908." Cloth.
- Commissioner of Education, Report of Commissioner of Education, 1907, Vol. I. Cloth.
 "Annual Report for 1907." Cloth.
- National Council of Commerce—
 "Proceedings of First Annual Meeting, December, 1908." Pam.
- Smithsonian Institution—
 "Annual Report for Year 1907." Cloth.
- Interstate Commerce Commission, Special Report No. 1, "Intercorporate Relationships of Railways in the U. S. as of June 30, 1906". Cloth. 1908.
 "First Annual Report of the Block Signal and Train Control Board." Pam.

- U. S. Dept. of Agriculture, Forest Service Pams.
 Cir. 152, "The Analysis of Turpentine by Fractional Distillation with Steam".
 Cir. 157, "A Primer of Conservation".
 Silvical Leaflets Nos. 15, 24, 18, 19, 21, 28, 30, 31, 32, 38, 40, 41, 35, 37, 42.
 Extent and Importance of the Chestnut Bark Disease.
 Progress in Forestry in 1907. (Reprint from Year Book).
 War Department, Report of the War Department, Vols. 1 to 10 incl., 1907
 9 books, cloth, 1 pam.
 Commissioner of Patents, Annual Report for 1907. Pam.
 Maj. Thomas H. Rees, U. S. Engineers, Chicago, Report upon the Improvement of Rivers and Harbors in the First Chicago Illinois District.
 Navy Dept. (Bureau of Steam Engineering), Annual Report of Chief of Bureau of Steam Engineering, 1908. Pam.

MEMBERSHIP

ADDITIONS TO MEMBERSHIP:

Frederic A. Bergbom, Chicago, transfer from Associate to.....	Active
Frank H. Bernhard, Chicago.....	Active
Carl W. Boynton, Chicago.....	Active
G. W. Bulley, Chicago.....	Active
Maurice L. Carr, Chicago.....	Active
David M. Craig, Chicago.....	Active
John Hornbrook, Chicago, transfer from Junior to.....	Active
Harry F. Kellogg, Chicago.....	Active
Frank E. King, Milwaukee, Wis.....	Active
Frank E. Lamphere, Chicago, transfer from Junior to.....	Active
Ralph G. Mansfield, Chicago.....	Junior
Albert B. Moore, Chicago.....	Active
James W. Phillips, Lewiston, Cal.....	Active
Thomas H. Rees, Chicago.....	Active
Wilbert M. Richards, Chicago.....	Junior

Corrected Addresses:

J. W. Beardsley, c/o W. M. Beardsley, Norwich, N. Y.
 S. P. C. Borson, Fort Garland, Colo.
 Lincoln Bush, No. 1 Madison Ave., New York, N. Y.
 Robert S. Draper, 6842 Perry Ave., Chicago.
 J. H. Fredericson, 100 James St., Syracuse, N. Y.
 Otto Gersbach, 347 E. 62nd St., Chicago.
 Josiah Gibson, 1616 Monadnock Block, Chicago.
 Wm. H. Harris, 225 N. Taylor Ave., Oak Park, Ill.
 E. C. Hasselfeldt, 2723 Jackson St., Omaha, Neb.
 A. J. Hemstreet, 314 E. Vilas Ave., Guthrie, Okla.
 J. A. Moskovitz, Plainview, Texas.
 L. S. Ricards, 7432 Emerald Ave., Chicago.
 A. S. Rosing, Marengo, Ill.
 E. R. Shnable, 1037 Stock Exchange Bldg., Chicago.
 Homer Thomas, 4055 Prairie Ave., Chicago.
 Edward Wilman, 225 Union Station, Washington, D. C.

WESTERN SOCIETY OF ENGINEERS

SECRETARY'S OFFICE, LIBRARY, READING ROOM AND MEETING ROOMS
1735 Monadnock Block, Chicago.

LIST OF OFFICERS FOR 1909

President.....ANDREWS ALLEN
First Vice-President P. JUNKERSFELD
Second Vice-President.....O. P. CHAMBERLAIN
Third Vice-President.....W. F. M. GOSS
Treasurer....A. REICHMANN

TRUSTEES

W. C. ARMSTRONG.....Term expires January, 1910
L. E. RITTER Term expires January, 1911
G. M. BRILL Term expires January, 1912
B. J. ARNOLD, W. L. ABBOTT, C. F. LOWETH.....Past Presidents.

The above named officers of the Society and three past presidents, constitute its Board of Direction.

Secretary and Librarian
J. H. WARDER

COMMITTEES

On Finance—P. Junkersfeld, A. Reichmann, John Brunner
On Publication—O. P. Chamberlain, C. B. Burdick, Wm. B. Jackson,
A. Bement, Ernest McCullough, E. N. Layfield, M. K. Trumbull, O. J. West.
On Library—W. C. Armstrong, L. J. Hotchkiss, E. N. Lake.
On Amendments—C. F. Loweth, W. L. Abbott, B. J. Arnold,
W. T. Reeves, M. K. Trumbull.
On Membership—L. E. Ritter, C. M. Denise, D. W. Roper.
On Entertainment—G. M. Brill, W. A. Hazard, James Lyman.
On Increase of Membership—S. T. Henry, F. W. Boldenweck,
C. W. Brooks, Arthur Lewis, M. W. Priseler.

THE ELECTRICAL SECTION

Wm. B. Jackson, Chairman, P. B. Woodworth, Vice-Chairman, for 1909.
K. B. MILLER.....1 year
E. N. LAKE.....2 years
W. L. ABBOTT.....3 years
Members of Executive Committee.

MEETINGS

Regular Meeting—1st Wednesday evening of each month except January
July and August.
Extra Meeting—Generally the 3rd Wednesday evening of each month except
July and August.
Electrical Section—Wm. B. Jackson, Chairman, generally the 2d Friday of
the month, October to May, inclusive.
Board of Direction—The Tuesday preceding the 1st Wednesday of each month.

NOTICE

From the dues of each member, \$2.00 is set aside as a subscription to the JOURNAL.

Journal of the Western Society of Engineers

VOL. XIV.

APRIL, 1909.

NO. 2.

COAL BRIQUETTING

MR. CARL SCHOLZ OF THE ROCK ISLAND COAL MINING CO.

Presented Nov. 18, 1908.

The making of fuel briquets is generally considered in connection with either one of the two problems,—the disposition of fine coal which cannot be marketed advantageously, or the production of a fuel which is superior to raw coal.

The surplus of fine coal in many fields is one of the great problems encountered, especially in view of the increasing percentage of the smaller sizes. The second subject is of interest to engineers and consumers of coal when high efficiency, smokeless combustion, and storage qualities are essential, and where anthracite, domestic coke, and other high grade fuels can be displaced.

Briquets have been made in England, Germany, France and Belgium for many years, and the production now aggregates almost 100,000,000 tons per annum, a part of which is exported to South America and Mexico.

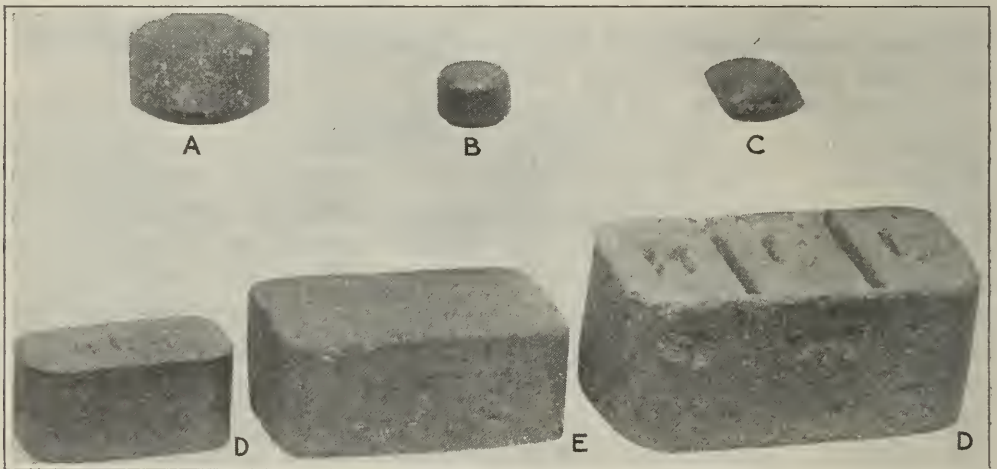
A number of briquet press installations have been made in the United States during the last few years, but only a small quantity of briquets have been manufactured, and with some exceptions the plants were short lived. The enormous increase in the coal production in this country, together with the low cost, and the accessibility of thick veins, has scarcely warranted coal operators in devoting much time and money to this subject, and where plants have been erected, it is believed that the conditions were not sufficiently investigated. A number of machines were manufactured or imported and sold to coal companies on the representation of results based on the experience of similar plants in foreign countries. It usually developed, however, that in some important features the results differed largely from the representations made, and in consequence of many failures, briquetting has been considered an impracticable proposition in this country.

For the purpose of comparison, it is well to mention the difference in the trade conditions prevailing in foreign markets and the United States. The cost of coal at foreign mines is much higher than in this country, (although wages paid to employees are much lower,) the extraction being much more difficult. The difference between the selling price of lump coal and the finer sizes in foreign countries

April, 1909

is much greater, and the cost of binder and wages of operatives are much less than in this country.

In several of the coal fields of the United States much of the fine coal is converted into coke or washed, but since not all coals possess cooking qualities and washed coal can only be used for steam purposes, the surplus of the finer sizes in the non-coking fields has seriously impaired the revenue of operators. The percentage of fine coal has increased in this country by reason of the adoption of solid shooting in the mines. The development of mechanical stokers and the increase in industrial plants in the Central Coal Field, including Illinois and Indiana, has largely absorbed the increased production of the fine coal in some fields, with the result that in such sections there is but a slight difference in the selling price of the coarser and finer sizes.



Samples of Coal Briquets.

A Renfrow Carbonets.

C Mashek Briquet, New York.

B New York Briquet Co.

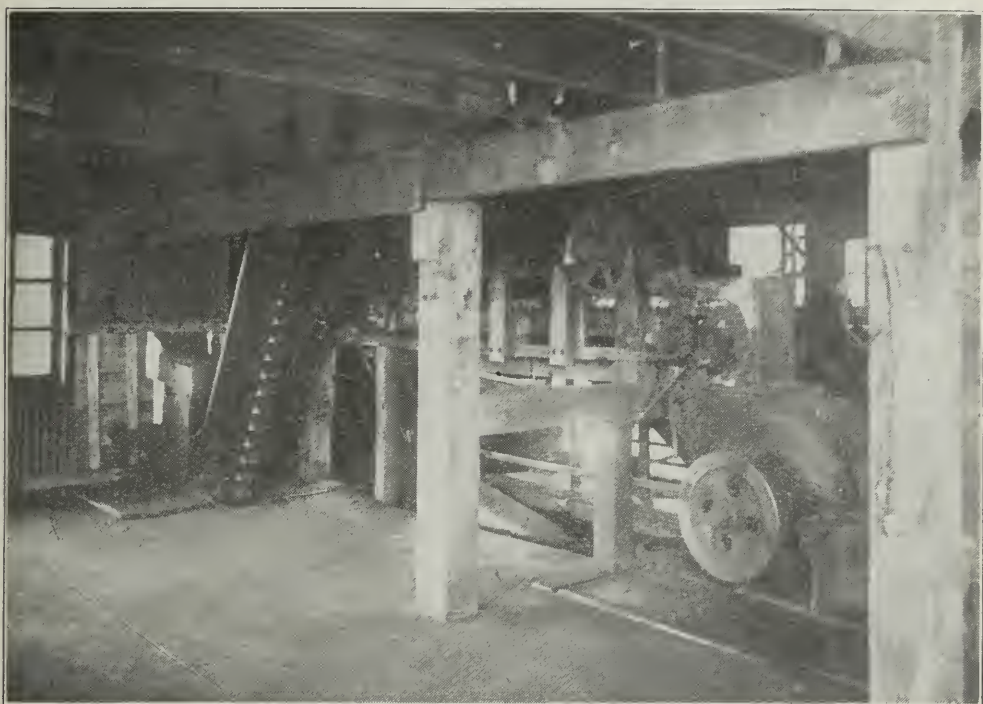
D Briquet Coal Co., New York—2 sizes.

E Johnson Briquet.

In West Virginia and Pennsylvania large quantities of coke are produced. In the southwestern states, however, where comparatively few coal consuming industries exist, the price of lump coal has constantly increased without any change in price of the smaller sizes. On this account careful investigations have been made with the view of disposing of the slack in the most advantageous manner. Several coke plants are in operation in that field, but since the surplus of slack is irregular, the ovens have to be cooled and re-fired according to the trade demand for coke. The yield of coke is low and the product must be marketed at the smelters in Mexico and Arizona. The high sulphur and ash content of the coke prevent its use for iron manufacturing purposes.

The washing of the fine coal offers a partial relief because on account of its improved quality shipment can be made to more distant points. Since the demand of that trade is largely for domestic

purposes, it soon became apparent that if the fine coal could be briquetted at a cost below the selling price of lump coal, this method would offer the most favorable solution; the plant could also be operated intermittently without the great loss that is involved in the cooling and re-firing of coke ovens; the investment for a given output is much less than for coke ovens. Briquets should be sold in competition with lump coal without depending upon such special trade conditions as apply to coke, which is governed by the metal market and the activity of the smelters.

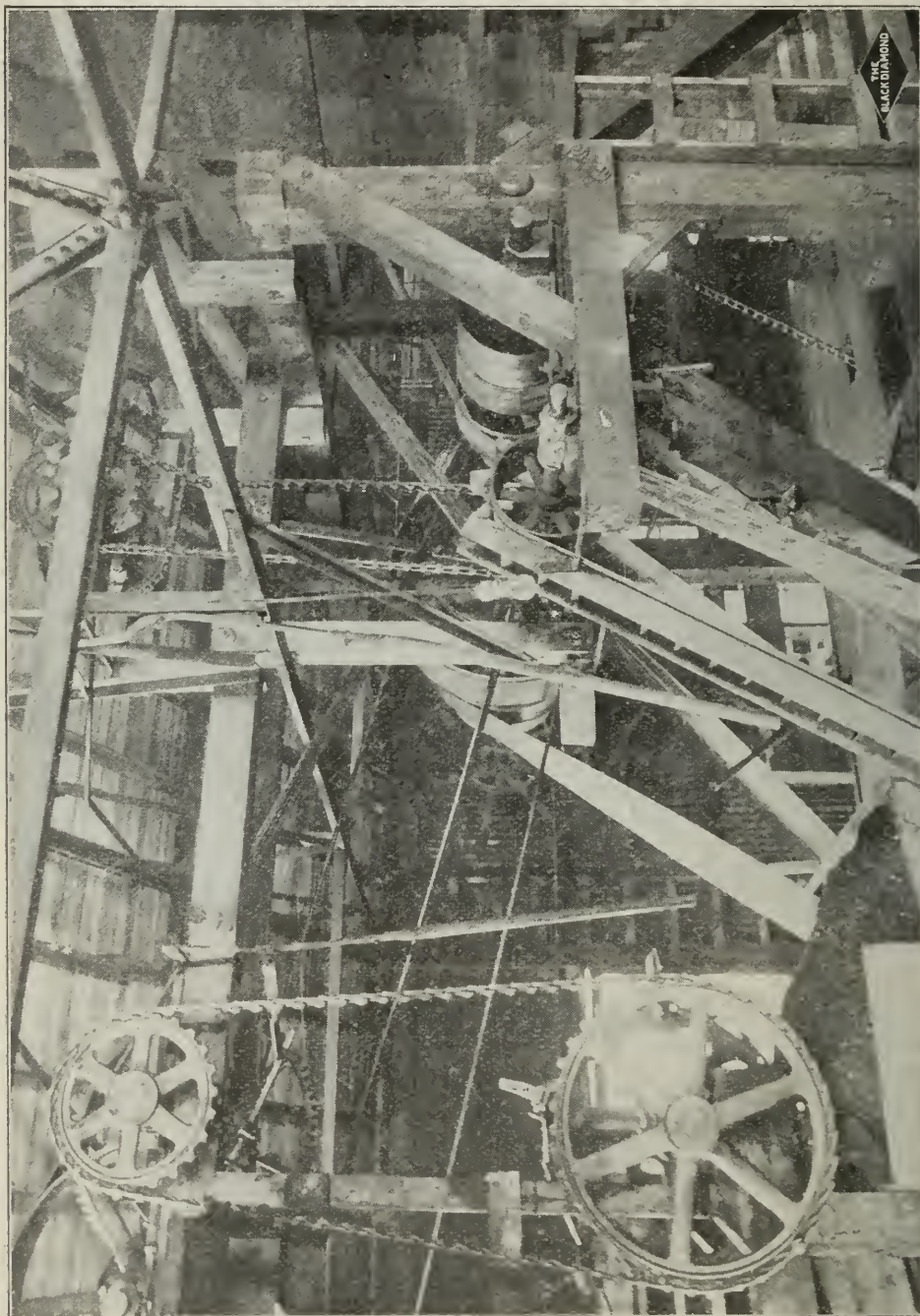


Mixing and Grinding Machine. Charging Floor, overhead.

A campaign of investigation was inaugurated which lasted nearly two years, and included all of the machines in use or built in this country. About that time the briquetting plant at the World's Fair, in St. Louis, was erected, and much valuable assistance was rendered by the engineers in the employ of the Geological Survey. Briquets were made from our coal on the various machines and tested under stationary boilers and locomotives. It was observed that no one process could be applied to the various coals briquetted, and that each particular coal required conditions which had to be separately determined. This point is made because manufacturers have frequently sold machines to lignite mines, which were especially designed for the briquetting of bituminous coal, and vice versa.

The requirements as to weight and shape of briquets vary with almost every grade of coal, not on account of the chemical composition of the coal, but more because of its physical properties. Broadly

speaking, it may be said that the lighter coals and lignites give best results when briquetted in larger sizes of from two to three pounds in weight. Ordinary bituminous coal should be briquetted in sizes



Elevating and Conveying Machinery.

of 10 to 24 oz.; high carbon or anthracite coal and coke dust give better results when briquetted in small sizes, weighing from $1\frac{1}{2}$ to 6 oz. The shape of the briquet is important, in so far as the surface exposed considerably affects the rate of combustion.

The advantages obtained by briquetting are, greater efficiency, ab-

sence of clinker and cinders, reduction of smoke on account of more perfect combustion, cleaner handling and absence of dust, better storage, and decreased loss due to degradation. Briquetting has very much the same effect on combustion as is derived from washing and sizing of coal, except that the fine particles of coal are held together under strong draft, as with locomotives, and are consumed more thoroughly. This can best be illustrated by partly burning a briquet and cutting it in two after quenching, when it will be found that coal of lesser coking tendencies will coke fairly well when briquetted. This is due partly to the addition of the binder, but mainly to the fact that the process of combustion can advance only at a given rate, being retarded by the compactness of the briquet. Where raw coal is fired, the coal, upon heating, cracks along the cleavages and laminations, resulting in an escape of gases which cannot obtain the proper admixture of oxygen, and, which, therefore, leave the fire-box unconsumed, and as smoke. The larger the lumps the more aggravated is this condition. Actual tests on locomotives indicate that briquetted slack, carrying 12% of ash, evaporated 14% more water than lump coal from the same mine carrying $7\frac{1}{2}\%$ of ash.

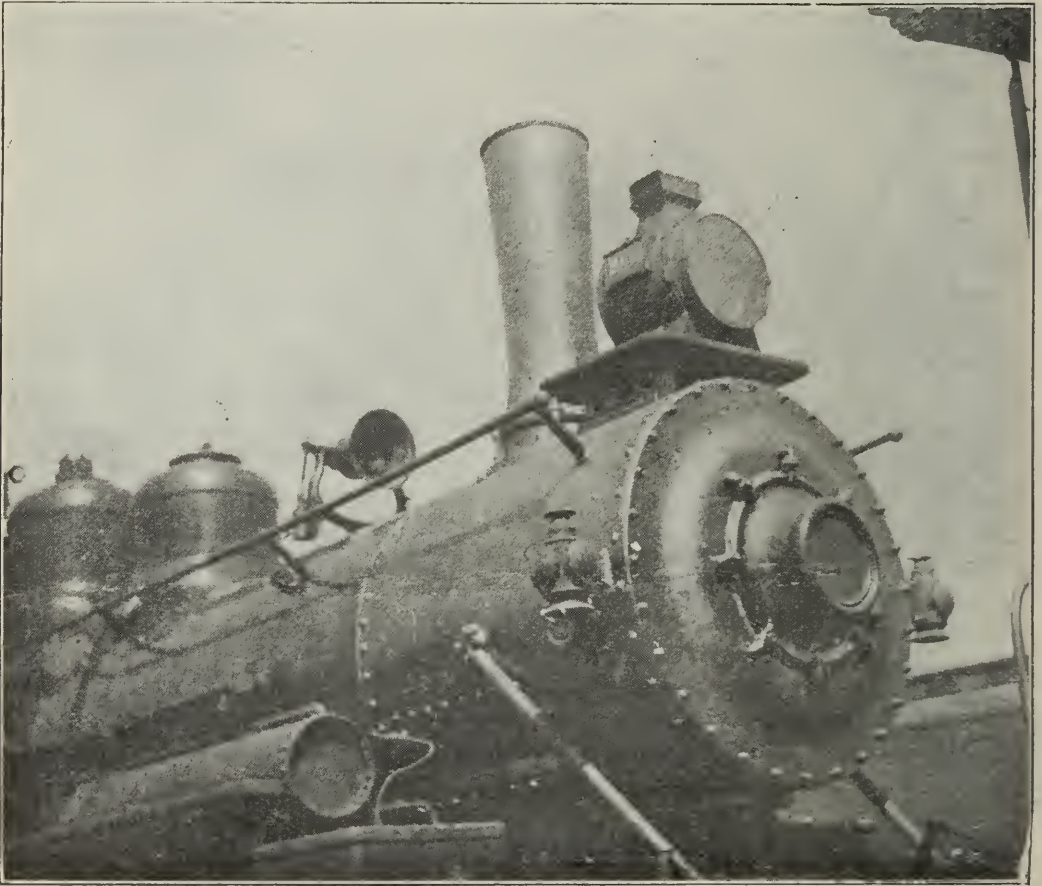
The selection of machinery is an important item and depends greatly upon the character of coal to be briquetted. There are two general types; the rotary press, where the coal is compressed into molds of two rolls held together by strong springs, and the plunger type, where the coal is compressed in a die by opposing plungers. For obvious reasons the roller type produces smaller briquets, and the plunger machines the larger sizes. Inasmuch as in most cases the coal mixture is heated in the briquetting process, the larger briquets require a longer time for cooling, and must, therefore, be handled with more care, preferably by hand, in sizes of two pounds and upward, before loading or storing. Due cognizance should be taken of this feature, considering the high cost of labor prevailing in this country, and preference is given to such machines as require the least handling by labor.

The largest item of expense in briquetting in this country at present is the cost of binder. The most available product, as established by our experiments, is pitch from coal or water gas tar. The percentages of pitch vary with its hardness and the different coals. In our case about 8% is required for satisfactory results. This pitch has a melting point of 90 deg. C.

The determination as to the location of a briquetting plant is of importance, and should include a careful consideration of freight rates on coal, binder, and the manufactured product, as well as the markets to be served. From these statements it may be said that a briquet installation requires a combined knowledge of trade and mechanical conditions, and should only be entered into after an exhaustive study of the subject. The education of the trade which is to consume briquets, is an important factor, and should be anticipated by the producer.

In view of the conditions prevailing in the Oklahoma coal field, after careful consideration our company authorized the erection of a plant, at Hartshorne, Oklahoma, and we point with some pride to the fact that this plant has been operating successfully for the last ninety days, producing briquets on a commercial basis. A description of this plant may be of interest:

The plant is situated on the site of an old mine yard, and is in close proximity to three mines. The coal, which is delivered at the briquet plant in drop bottom cars, is of pea and slack size, screened



Smokeless Combustion with Carbonets.

through one inch perforations. As soon as the cars are loaded at the mines, they are covered with water-proof tarpaulins to exclude the rain; the concrete-lined unloading-pit is also covered by a shed to keep the coal dry. A bucket elevator, of 50 tons capacity per hour, carries the coal to the top of a steel storage bin, where a rotary screen separates the pea coal, which is then reloaded for shipment on the opposite side. The storage bin has a capacity of 150 tons, or about 20 hours supply. A drag conveyor, 50 ft. centers, carries the coal from the storage bin at the required rate to the press building. The intervening space between this building and the bin is used

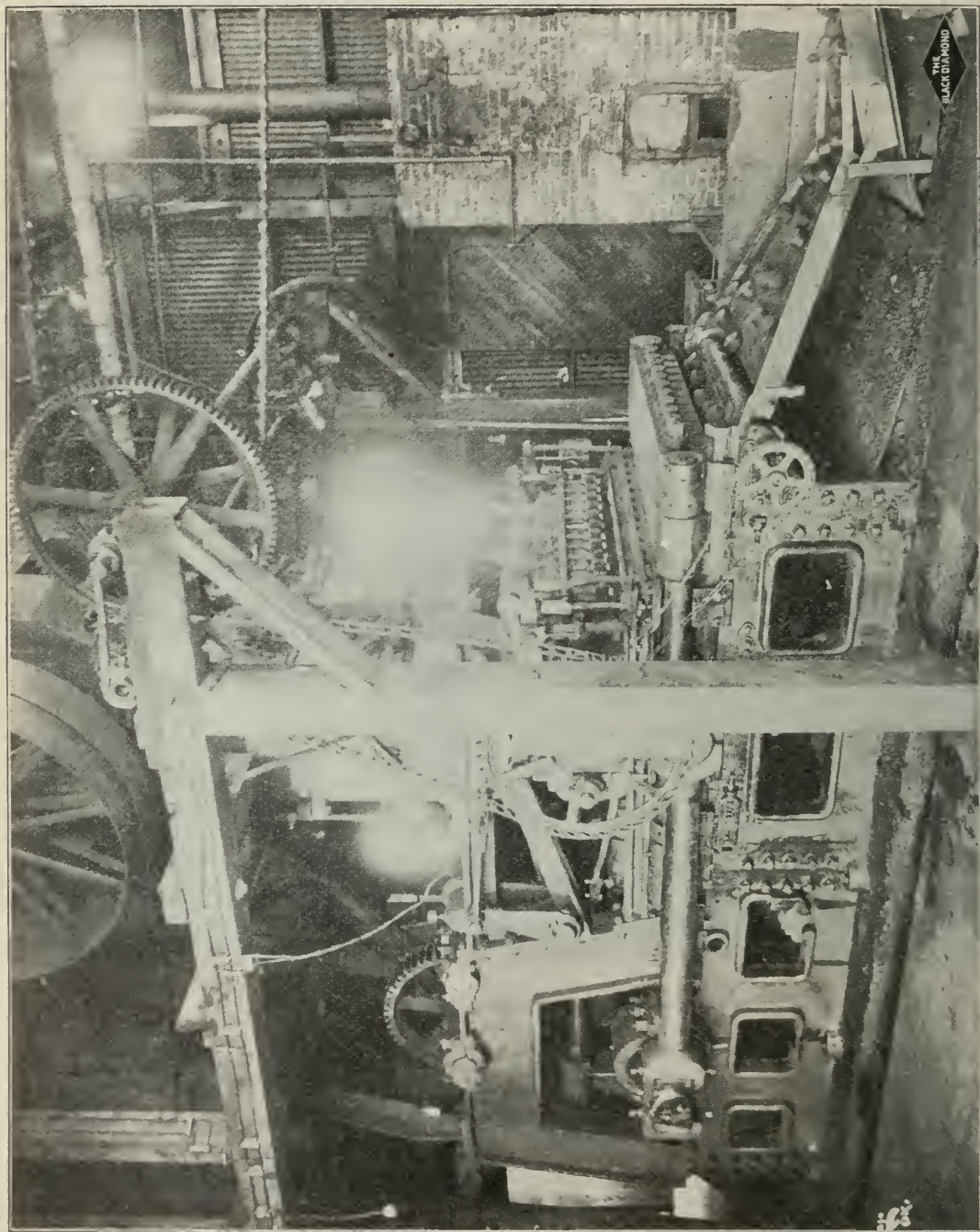
for the storage of pitch and has a concrete floor. The pitch is cracked in a small mill and elevated into a feed box, located immediately in front of the drag conveyor discharge. The coal and pitch are measured by trough conveyors, passing under the two respective bins, and traveling at the required speed to carry 93% of coal and 7% of pitch. This is then delivered to a Jeffrey disintegrator to thoroughly mix it; after which it is elevated to the top of the press and emptied into the heaters. These heaters are vertical cylinders having revolving agitators. The heating is accomplished



Smoking Locomotive—Bituminous Coal.

by the admission of superheated steam which comes in direct contact with the coal. Since this steam contains some moisture, it is essential to have the slack as dry as possible in order to reduce the quantity of binder, it having been found that wet coal requires a greater percentage of binder than dry coal. It may be said here that washed coal does not briquet as well as raw coal, due possibly to the very fine film of water which envelops each particle of coal, thus making the mass less cohesive. From the heaters the coal drops directly into the die-filler, and at each revolution of the roller press, the two sets of twelve dies each, are loaded and the charge compressed and

ejected alternately. The briquets, which weigh about 13 oz., are fairly warm when they leave the press, and are carried on a belt conveyor, serving as a cooling table for about three minutes before reaching the cars, where they are at once loaded for shipment.



Renfrow Briquet Machine. Making Carbonets.

The power for this plant is furnished by a 100 H. P. boiler, which drives a 13 by 14 in. automatic Ball engine, and furnishes the steam for the superheater.

Care is taken to prevent iron or other hard substances from getting into the mill and press, and a magnet is installed for this purpose.

This plant was designed for two presses, although at this time only one "Renfrow" machine is installed, having a capacity of nearly ten tons per hour.

The briquets (known by the trade name of "carbonets"), are sold throughout Oklahoma, Kansas, Texas and Arkansas, principally for domestic purposes and are generally liked by that trade. They are clean to handle, and make very little clinker. While the flame is not as long as from lump coal, the briquets make a good grate fuel and hold fire for many hours. It is anticipated that they will be adopted for steam purposes in thrashing and other portable engines where the grate area is comparatively small



Carbonets by the Carload.

If the cost of binder can be reduced, it is likely that briquets will be used for locomotive and steam purposes, although the high cost at this time is prohibitive. There is a large field for engineers in the development of binders for briquetting. There are many secret binders now offered which, however, should be closely investigated in order to prove the claims of the inventors.

The press which we use is manufactured by the Renfrow Briquet Machine Company, of St. Louis, Mo. The other parts of the plant were assembled from different manufacturers, and are not patented.

A laboratory is operated in connection with this plant, and the boiler is equipped with apparatus to enable the determination of the

fuel values. The laboratory experiments include an examination of each car of binder purchased and tests of briquets in order to keep the binder down to the minimum. Each per cent of binder means a cost of 15 cts. per ton of briquets; therefore, it is essential to prevent any waste. Experiments are also made to determine the degradation of briquets when exposed to the weather and the absorption of moisture. It is safe to say now that pitch briquets can be stored without any appreciable loss for two years. This is regarded as a point of much importance, since fuel can be held in reserve without having to be reloaded, as is the case with coal, to prevent loss by degradation.

In Westphalia and Bohemia lignites are briquetted with but a small addition of binder, or in some cases without any, by the use of very high pressure. This lignite contains about 50% of moisture when mined, and is dried to about 10%, and then compressed under 150 atmospheres.

Some tests were made on these machines with Texas lignites, and briquets of superior appearance were produced; the fuel value, however, has not been established. Similar attempts have been made in the briquetting of peat, but so far as is now known they have not been a commercial success.

DISCUSSION.

Mr. Warren R. Roberts, M.W.S.E.: Have you made any experiments along the line of breakage, in shipping the briquets?

Mr. Scholz: The breakage has been determined by following up four or five cars, and the reports we have indicate that about one briquet in every two-hundred was broken—less than $\frac{1}{2}$ of 1 per cent.

The particular point to be observed in briquetting is the equal distribution of the binder with the coal, and the largest cause for failure lies in that one point. The measuring of pitch is exceedingly difficult. Seven pounds of pitch mixed with ninety-three pounds of coal is a very wide range of ratios, and the tendency of the machine operators is to make briquets irrespective of cost; therefore, in order to protect themselves they are very apt to put in more pitch, little realizing that 2 per cent. more of pitch than the required amount may mark the line of loss and profit. As 2 per cent. of pitch wasted would mean 30 cts. loss; this, would be a big profit on Illinois coal, therefore the main proposition is in keeping down the pitch proportion, and I am investigating one or two methods whereby we can get a better distribution of the two materials.

Mr. Roberts: How do you get the percentage now?

Mr. Scholz: The coal is received in the dry conveyor from the storage bin and discharge into a little feed hopper. Under this feed hopper passes a trough conveyor which has a gate and which takes out the coal and loads to a certain height. Immediately in front is another conveyor carrying the ground pitch. These two conveyors are geared together so that every 93 pounds of coal carries with it

the 7 pounds of pitch. The material drops into a boot, is elevated to the top of the press and passes into the heaters.

Mr. Roberts: Do you have any trouble with your conveyors clogging after you put in the pitch?

Mr. Scholz: No, very little. Pitch will clog only when handled by itself. The admixture of 2 per cent. of coal will prevent sticking.

Mr. Roberts: In what form do you receive the pitch?

Mr. Scholz: The climatic conditions in Oklahoma are very trying, and not having had any experience in handling pitch we started out in August by receiving it in barrels. The barrels represent 10 per cent. of the weight, so we were not only paying more for the pitch but more freight as well. We began to investigate bulk shipping and find that it can be done easily in summer or winter. We expect to ship it in open coal cars. The pitch is run into moulds holding about 200 pounds each.

Mr. Roberts: Does the pitch run again after it is unloaded?

Mr. Scholz: No, not to any appreciable extent.

A Visitor: Has the temperature any influence on the briquet?

Mr. Scholz: The temperature of the briquet by the time it reaches the car is 60 to 65 deg. Fahr. so it is fairly cool. When it leaves the press the temperature is from 90 to 95 deg. Fahr. After the briquet has been made for a day, it will stand any reasonable drop without breaking, but when it first comes from the press it has to be handled carefully. It is essential to have the briquet as cold as possible as it leaves the press.

A Visitor: The outside temperature is what I refer to.

Mr. Scholz: That has not yet been determined.

Mr. H. B. McFarland, M.W.S.E.: What steam pressure do you use and what degree of superheat is best for heating the mixture?

Mr. Scholz: The boiler carries 125 pounds of steam, which we superheat to about 400 degrees. The superheater is a "home-made" affair and I am trying to get a better one.

Mr. McFarland: What type of superheater do you use?

Mr. Scholz: The superheater is simply a mass of coils located in a furnace. These coils end in a pipe connected with the vertical heaters into which the coal is dumped.

Mr. Geo. M. Mayer: How close do you come to your percentages of mixtures?

Mr. Scholz: We find that 7 per cent. is the requirement for our particular coal. We tried to make it 5 per cent., but the briquets would not stand it.

Mr. Mayer: How close can you regulate the discharge of the coal and binder? Will the discharge of the materials always be just seven per cent.?

Mr. Scholz: We have tested about 100 briquets out of every car, and the variations do not exceed 1 per cent. one way or the other. If the coal is wet, the operator is very likely to put in more pitch, but our Chemist and Briquetting Engineer look after this mat-

ter and keep the amount of pitch down. An effort is made to have the coal come to the press as dry as possible. The admission of live steam creates more or less moisture and in compressing the charge there is more or less water pressed out of the coal.

Mr. Mayer: Do you have to keep a man at the mixer?

Mr. Scholz: No, one man feeds the pitch. He breaks and throws it into the mill, looking after the valve occasionally. Particular care is taken to see that the feed is always working in good order.

It is a very simple proposition, and as far as I know it is the most effective, although I still hope to improve it and am now investigating a measuring device made in Chicago, in order to get a device to feed the pitch in a constant stream.

Mr. Mayer: Could you use automatic weighing scales?

Mr. Scholz: Several devices have been tried where platforms were built with collapsible doors and pitch was spread on them, but they required so much hand labor that we did not regard them as feasible.

Mr. Roberts: You showed that in three different mines the percentage of ash varied greatly in the course of a day. Do you find it necessary to vary the percentage of binder?

Mr. Scholz: The percentage of ash seems to have no bearing on the material. We made some experiments on washed coal, but found that, although thoroughly dry, it required the largest percentage of pitch before we got the same degree of hardness. It may be said, however, that it makes a better briquet.

Mr. Roberts: The objection is raised that by using a pitch binder the briquets will disintegrate under heat. Have you found the same trouble?

Mr. Scholz: We find no failure on account of melting or cracking. Briquets seem to coke even though the raw coal has no coking qualities. Coke or anthracite coal briquets even indicated more or less coking tendencies.

Mr. Abbott (Chairman): The first briquetting enterprise I ever heard of was established in the neighborhood where I lived when a boy.

A man named Silas Dodge and called "Peat Dodge" owned a tract of bottom land near Albany, Whiteside County, Illinois, and as it had an area of two square miles, all underlaid with a bed of peat thirty feet in depth, he readily calculated that he owned millions of tons of peat, which at an assumed value of, say, two dollars a ton would make him fabulously wealthy. Dodge built an experimental briquetting plant on a scow, which he floated in the ditch cut by a machine like the modern ditching machine, and with this apparatus he briquetted peat more than forty years ago. But in spite of the alluring figures which he was able to make, he never succeeded in interesting capital in his enterprise, and after a long struggle was finally overwhelmed with debt and lost his property, when as he be-

lieved, fortune was almost within his grasp. Dodge long ago passed out of this world, but his peat still remains in the cattail bottoms, awaiting the next briquetting exploiter to come and develop its great wealth.

Another briquetting enterprise came to my notice a year or two ago. I thought at first it was quite as alluring as the one just described. The proposition was to mix a small proportion of coking coal with anthracite dust and press it into a briquet, a small amount of binder being used. The theory was that when the briquet burned, the small amount of coking coal which it contained would fuse throughout the mass and cement it together firmly. It was represented that down in Pennsylvania there are millions of tons of anthracite screenings which can be had for a few cents a ton, and which can be briquetted for a few more cents a ton and sold for \$8.00 a ton; profit, \$7.50 a ton!

That scheme was a good one, but, like the one previously mentioned, it did not work out. I simply mention these schemes to show you the possibilities in the briquetting business. I regret that, on account of being so busy, I cannot take up this work myself.

There are some gentlemen here who have been making small profits in coal, and I should like to hear them discuss the possibilities of the briquetting business in connection with the coal business.

Mr. A. Bement, M.W.S.E.: The most important remarks that I can probably make concerning the briquetting business, are in relation to unsuccessful ventures therein and the reasons therefor.

Within the past two or three years nearly every man or set of men who had a briquetting scheme to exploit, called upon me. Without an exception none of these people were familiar with the coal business, trade conditions, or character and composition of the fuel with which they hoped to deal; in fact, they were altogether ignorant of the many important details which make briquetting a strictly scientific business, and the remarkable feature was, that none of these promoters were seeking information or engineering advice. Some of them had gone so far as to obtain or develop a press or a binder, and were looking for money to either put the press in motion or try the binder. Just what the result will be in the case of this particular lot of promoters it is too early to predict, but viewed in the light of the experience of others who went before them, it is possible that they will cease their efforts at briquetting when they have exhausted all the money that they can procure for the purpose. It is amazing to contemplate how people, absolutely ignorant of the many complicated problems involved, will rush into the briquetting business with such confidence as to the outcome. For example, a man recently came to me with a very good briquetting machine. He knew a great deal about the business along certain lines, but was entirely unfamiliar with the coal business and the matter of burning coal. He proposed to buy high grade nut coal, grind it and re-form it into corresponding sized briquettes, at a cost of 80 cts. per ton. Thus,

for illustration, a customer would, on the one hand, be offered fuel which had been briquetted by nature for, say, in the case of washed coal, \$2.60 per ton f. o. b. Chicago, and on the other hand, briquettes artificially made out of the same coal at an added cost of 80 cts. per ton, or in other words \$3.40 per ton, excluding any profit to the manufacturer. This man labored under the delusion that there was some peculiar and undefinable quality added to the fuel which gave it an increased value during the process of briquetting. For illustration, it was desired in a certain case to ascertain the heating power of a new briquetted fuel. A calorimetric determination was made, which showed that it was equal, so far as combustible matter was concerned, to a pound of good bituminous coal, but the maker of this briquet was greatly astonished at the result, believing that it should have a very much higher heating power, and it was necessary to explain that the heat producing elements in the fuel consisted of carbon and hydrogen, and that it would be impossible to use any heat producing material which would give higher results.

The most remarkable feature of the matter thus far, is the absolute lack of familiarity with trade conditions, on the part of the people attempting to get into this business. It is not my purpose to discourage the consideration of briquetting propositions, but on the contrary to call attention to the fact that these efforts have proven failures, and why the general briquetting scheme has acquired so much discredit among practical people.

The United States Geological Survey in a report on briquetting, calls attention to six or seven plants which are in operation, among which, I suppose, Mr. Scholz' equipment is mentioned. If so, I would venture the opinion that his is the only plant among the number working successfully. In this case, Mr. Scholz studied the problem from every standpoint, and there were several things to take into consideration aside from those of a strictly technical character. Two or three commercial phases of the coal business were involved, all of which had attention. Every feature and detail of the matter was thought out and followed to a logical conclusion, with the result that Mr. Scholz has probably the only successful briquet making plant in this country.

In conclusion, the most useful item I could offer in the way of discussion to this interesting paper, is to suggest to would-be promoters and inventors, that if not qualified themselves, they employ a competent person to diagnose their prospects in detail, before they proceed to spend any of their own or their friends' money.

Mr. Roberts: Mr. Bement's remarks bring out very pointedly one more question, and that is,—does not the briquet, from its very nature, without regard to its size and shape, produce a greater amount of heat from the same amount of coal than egg coal of the same size in the natural state—due to the fact that the briquet does not laminate and easily disintegrate in the fire as a piece of egg coal would?

Mr. Scholz: Yes, that is true.

Mr. Roberts: Is that an established fact?

Mr. Scholz: A briquet of the same size as a lump of coal, made from the same coal, will evaporate more water than egg coal, due to the fact that it is made up of small particles, while egg coal will crack and a lot of the gases will be lost.

Mr. J. D. Dering: I do not know that I can discuss this subject at all, but I am associated with Mr. Scholz, in a small way, and he has told me a good many things about briquets. I was not sure that he had told me all he knew and so decided to come here this evening, thinking I might learn something more.

The coal men are all trying to do something with this fine coal. They all have in mind the idea of a perfect briquetting plant and hope they will find one some day, and one that will make marketable briquets. I can appreciate what Mr. Bement means when he says that the average man exploiting a briquet enterprise, does not know the trade conditions, but I cannot quite understand his remarks, in view of publications I have seen, bearing his signature, showing the value of our Illinois slack coal as a steam producing proposition as against those of the eastern coals, which indicate that if we can briquet our slack coal and put it on the market in shape so that it can be handled without smoke and without distaste to the average fireman, it is one of our great sources of fuel; that we would have an article that would command a much higher price than the raw article. As I remember the figures, Illinois slack at \$1.45 figured 85c per ton better than Jackson Hill, Ohio. If we can add that 85c to \$1.45, we are getting somewhere near the price at which a briquet can be made. To the coal men the subject of briquetting is an interesting one.

Mr. Allen, M.W.S.E.: I have listened to Mr. Scholz's paper with great interest. I might say that we are well acquainted with and have gone over the matter many times. I wish to state that the prime reason for his success is that he has gone into the matter carefully, step by step, making all necessary tests, and consequently if there was a successful result to obtain, he obtained it. He went into the matter like an engineer should go into it, and I congratulate him on his great success.

Mr. R. H. Kuss, M.W.S.E.: Many things recommend the briquetting of bituminous coal when intelligently undertaken, and it is probably a fact that the average person is wholly unfamiliar with the subject. What information I possess was gained by a cursory observation of their manufacture in St. Louis, at the U. S. Geol. Surv. Fuel Testing Plant, where two types of machines were in operation; also by using the product as a domestic fuel, applying it to a hand-fired boiler, and observing results in locomotive fire boxes on several of the runs out of and around Chicago.

Briquetted fuel is manufactured for the purpose of creating from a high volatile coal, either a form of fuel easily transported or one that lends itself to a slow rate of combustion. The former is strictly

a commercial problem, and the latter a combustion problem. Briquetting is resorted to when the character of a portion of the mine's output (the slack) is such as to make it unprofitable to attempt its distribution in competition with the better grades produced. A product having the quality of a slow rate of combustion becomes important to the exclusion of the commercial feature when the basic fuel is capable of use as mined.

By far, the more interesting portion of the subject concerns itself with briquets as having an influence on combustion, although, from the attitude of the speaker, it is easy to see that many complicated questions surround the commercial aspects.

Briquets, when made in as dense a form as exhibited here this evening, possess a slow rate of volatile distillation, owing to the fact that coal is a poor transmitter of heat by conduction, however readily it may respond by the generation of heat when subjected to high temperatures in the presence of oxygen to carry on the combustion process. It has come to my notice many times that briquets (especially the large Renfrow form), after being subjected to high temperatures of fire boxes when cooled and broken open, show a distinct gradation from the original briquet fuel in the interior to the last stage of fixed carbon on the outside. I have sometimes wondered why briquets do not disintegrate in the fire, taking into consideration the mechanical pressure exerted in their manufacture, and have concluded that the use of a high steam temperature during manufacture serves the purpose not only of obtaining a homogeneous and plastic mass but also vaporizes the hygroscopic moisture of the coal itself. This, passing off at the time of and immediately following the compression of the mixture, is not readily reabsorbed, owing to the mechanical structure of the finished product. Consequently, in the combustion process there is little moisture to evaporate, and the briquet is not subjected to stresses due to evaporated moisture, which tend to break the briquet apart. This condition is not met with in the use of lumps of bituminous coal, which crack and split because of the internal pressure exerted by the evaporating moisture. By reason of the fact that the briquets do not disintegrate, the volatile distillation of the fuel is extended over a much greater period of time.

By the delayed distillation of the fuel we are able to accomplish much with briquets in the way of smoke prevention. This is readily understood when we remember that the sole reason why smoke is ever created is because flames, indicating only a partial step in the combustion process, if allowed to come in contact with relatively cool surfaces, even though other conditions of air and adequate mixture exist, are prevented from continuing the combustion process, and soot is the result. The smoke prevention process becomes more difficult as the flames become greater in volume, since the limits of our furnaces, even when of a type considered good, are usually not adequate to accommodate a high rate of gas distillation. This con-

dition is met with in all hand-fired furnaces for a short period immediately following replenishing the fuel-bed. Any means that tends to reduce the quantity of partially burned gas delivered within a definite period, considering a fixed combustion, accomplishes just that much toward reducing flame volumes and overcoming smoke. A uniform gas distillation is naturally the best method for obtaining combustion within the available combustion space, and briquets materially aid in securing this condition.

Unfortunately, the virtue of slow gas distillation is not entirely satisfactory where a manufacturing establishment desires to generate power from the units and at the rate usually employed. In such cases the briquet is excluded unless extra draft facilities are provided, a matter perfectly feasible in attainment.

In those places where it is desirable to have a clean fuel, both at the firing and chimney ends, and to deliver a low, steady, heat-generating duty, as in domestic furnaces, fire-place grates, stoves, apartment house boilers, office building and other heating plants, the briquet offers a solution to the problem. In fact, briquetted fuel seems to offer the only permanent solution of the smoke problem in the cases cited, so long as our heating equipment remains in its present generally accepted form. The truth of this statement is manifest only to those who have used the form of fuel under discussion to-night.

Ash without clinker and generally free from combustible matter, a fuel-bed better left alone and not poked, something requiring infrequent attention, none of the troubles incident to furnace and chimney cleanings, all combine to cause us to regard the briquet as a rational way to use the products of our own mines. This would encourage us into the belief that eventually we may lose our dependence upon anthracite and the semi-bituminous coals of the Eastern fields.

Mr. C. W. Naylor, M.W.S.E.: It is said that coal briquets are made from slack. I suppose they get that slack from Pennsylvania, because we are told the slack in Illinois has been exhausted. I do not think enough stress has been laid on the importance of those briquets to steam engineers. I believe, as has been intimated by Mr. Bement and Mr. Kuss, that there will be a decided market for briquets, even at a cost in advance of the natural coal. As Mr. Kuss says, this will be a solution of the smoke problem, even though the briquets will require more care, and I believe there is a market for a good coal briquet if put on the market for anywhere near the price of lump coal.

CLOSURE.

Mr. Scholz: I think I covered all the essential points, in my paper.

In regard to the storing qualities of briquets,—to large steam consumers and especially to railways, this is an important factor. Bituminous coal has to be loaded up every year to prevent too great a

loss by degradation. The loading up of storage coal usually occurs after the need for coal is passed. In other words, storage coal is held in reserve to guard against shortage, to use on occasions of excessive demands, or to guard against snow storms, etc. Immediately after the winter period is passed, the railroad companies use up the coals they have in storage. Therefore the storage coal is used at a time when the mines want the business, and with briquets this could be overcome, for they could be kept on the ground two or three years. In this way the railroad companies would be saving the cost of unloading and loading, and would be out simply the interest on the investment; this would be much less than the unloading and reloading and the loss due to degradation. I am carrying on some experiments now in that direction which I hope will be of value and interest.

DEVELOPMENTS IN ELECTRIFICATION OF RAILWAY TERMINALS

BY H. H. EVANS.

Presented Dec. 2, 1908.

Steam railroad electrification may be expected to come from three directions. An electrification may be decided upon because the continued operation of steam locomotives through a tunnel or through a city is deemed to be a public nuisance. It may be decided upon because of the savings which can be made by electrical operation instead of steam operation, or it may be decided upon as a matter of larger policy on the part of the railroad company, either for the purpose of attracting more travel or to get more movement over congested trackage. In any of these, the density of traffic is the dominating factor. To lead to electrification because of the first reason, the traffic must be sufficiently dense to make the nuisance large enough to be taken into account. One or two trains a day through a city may be unobjectionable, while a large number of steam trains a day passing through a city district may become almost intolerable. To lead to the adoption of electrification because of the savings that may be made, there must be a sufficiently dense traffic for the aggregate of the savings per train mile or per ton mile, to be sufficient to balance or over-balance the fixed charges on the added investment involved. The necessity of getting more movement over trackage, presupposes a density of traffic sufficient to make the movement over the trackage by steam more or less congested, and to make it worth while to attract more traffic as a matter of policy, there must be a nucleus of traffic to start from.

The determining factor, then, in the electrification of steam railroad trackage is density, and density of traffic is the characteristic of terminals; consequently terminal working presents the most fertile field for this development.

Electrification receives its largest consideration, from the public at large, owing to its obviating the major part of the nuisance incident to the operation of steam railroad trains through cities. There is secured by it, practically, freedom from smoke, smell, dust, noise and cinders. The smoke nuisance constitutes the larger nuisance incident to steam locomotive operation. It constitutes a larger nuisance on terminals than on through lines because of its concentration and because of the necessity for a large part of the terminal patronage to expose itself daily to the path of the smoke. For the man who has a long railroad trip to make, the presence of the smoke is not so much of an evil as for the suburbanite who morning and evening must have it with him, or the dweller along the railroad right of way who sees his property constantly damaged from it. Locomotive smoke is particularly aggravating, because it is concentrated along a route lying in many cases through

the best residence districts or through business districts; because the smoke is delivered low down between narrow house walls where there is little chance of dissemination; because of poor combustion within the locomotive, and because of the large personal element involved in any attempt to reduce it to a minimum. The steam jet employed in a locomotive smoke stack, the rapid rate of combustion and the small exit for the products of combustion from the smoke stack, combine not only to make more smoke than a stationary plant, but to lift cinders and finely powdered coal into the atmosphere and spread it along the right of way. In addition, ashes are being dropped along the track and scooped up by the passage of the train. The intermittent demand for steam in a locomotive also tends to imperfect combustion. The steam of the steam jet is an evil of itself and a magnifier of evil in that it converts the sulphur dioxide of the furnace gases (comparatively inert when perfectly dry) into highly corrosive sulphurous acid.

Certain noises incident to steam operation are objectionable, such as the puffing of the exhaust, the clank of the running gear and such pounding of the track as may come through the use of a reciprocating instead of a rotating motor. These nuisances, of course, are absent with the large central power plant outside of the residence and business districts and provided with efficient smoke preventing devices.

The maintenance of such nuisances, in addition to being disagreeable to the public, is injurious to public health and tends to depress property values along the line of route both because of the positive damage done from dirt and gases and from the unattractive means of transportation offered. Costly damage is done to merchandise and a large amount of money required to be expended by nearby occupants for cleaning buildings and structures and keeping the same in repair; this is directly chargeable to the nuisance. With the operation of electric trains, rather than steam trains, some decrease in fire loss may be expected, and the people's lighting bills will be smaller.

The public nuisance of steam operation may also come from the steam operation constituting a public danger. This is particularly true in cases of steam operation through tunnels and over constricted trackage. It is because the operation of trains by steam through their tunnel was considered a menace to public safety, that the New York Central R. R. was required by legislative act to operate its New York terminal electrically. In the steam operation of the St. Clair tunnel there were cases of asphyxiation of the train crew through the parting of a train in the tunnel filled with gases. While it did not require a public act, because trains were never operated therein by steam, it was because steam operation would be a nuisance, that the Paris-Orleans line electrified their tunnel entry into their Paris terminal and the Baltimore & Ohio R. R. its terminal entry into Baltimore. The working of trains by electricity in

such places removes the obscuring of signals by smoke, admits of the installation of efficient lighting and mechanical devices, provides a much more certain controlling of the train at danger points and provides physical comfort, and good vantage point for the operator in the cab of the electric locomotive or motor car, which tends to increase his alertness. The saving which may come from electrical working may be looked for at a number of points: In the first place the absence of dust, dirt and smoke leads to longer lived furnishings and less wear and tear on the rolling stock, and also to a lessened cleaning expense. It is probable that the coaches under electrical working will require cleaning at the end of the run just as they do at present with steam power, but while there is as frequent a cleaning there is not so laborious a one. Dusting off parts of the cars or wiping them lightly with a rag will take the place of a hard scrubbing, the latter not only costing more in that it takes more time and labor, but also having an extra expensive effect in that the hard rubbing removes paint work and varnish and otherwise damages the cars.

The absence of smoke should result in longer lived steel work in bridges, viaducts and other metallic structures adjacent to the track. These are rapidly eaten away because of the sulphur contained in the coal burned in the locomotives. In a recent inspection of a structure in Boston over a main track railroad after about 15 years' use, examination disclosed that the under part of the structure was very badly corroded to a depth of approximately one-eighth of an inch, diagonals in places being corroded entirely in two and the outstanding web of some angles having entirely disappeared. Above a wooden flooring in the bridge-work where the metal work was shielded from the action of the gases, only a negligible amount of corrosion had taken place.

A greater annual mileage capacity is available from the equipment by electrical working than by steam working. This comes, first, because of the higher speeds obtainable by electrical working, and second, by reason of the fewer repairs necessary for the electrical equipment and consequent larger number of days available for service throughout the year. There should be lessened switching and added movement under electrical than steam working. This is particularly true in the case of suburban trains, where instead of there being a necessity for the train to be run around a wye, or the locomotive to switch over from one end of the train to the other, it will only be necessary for the motorman to proceed from one end of the train to the other for his trip in the opposite direction. Compared with trains hauled by steam locomotives, in some cases, there will be saved the trip of a train to the storage yards for cleaning and back again and the trip of the locomotive to the water tank or to the roundhouse for grooming before the next run. This has been found, for instance, in the operation of the New York Central R. R. terminal, where an electric locomotive from an incoming train,

on arriving switches immediately to the head of an outgoing train and in a few minutes is bound out on another trip.

Electrical working of course, would mean a greater economy in coal consumption. This is partly due to the even load imposed on the power house boilers and prime movers against the violently fluctuating load imposed upon a locomotive in terminal service; the tendency of the power house, of course, is for the larger increments of load of individual trains due to acceleration, to be balanced by the lessening of the demand for power from the trains which are stopped; while the load may vary throughout the day we shall have fluctuation replaced by readily predicted variations for which we can vary the units in service in order to bring about economy. There is probably no more ably developed mechanical device, all things considered, than the steam locomotive. There are very few that will equal it and certainly none that will surpass it, but the fact remains that the locomotive is a compromise. Certain inherent restrictions limit its development in every direction; the track gauge, considerations of weight, of space, the necessity for quick steaming, the wide range over which it must be worked, these and a host of other considerations lead to compromises.

In the supply of electrical motive power, choice is no longer cramped and electrical working permits us to choose each element of the whole so that it will give the highest possible efficiency.

As a result we find, roughly speaking, that on terminal operation the fuel consumption by electrical working, despite the losses of transmission, conversion and distribution, is one-half that of the steam working. This is a smaller factor in Chicago than in other parts of the world. With electric current produced, as it can be in large power houses in Chicago, at a works cost of approximately four mills per kilowatt hour at the switchboard, compared with locomotives burning coal which is secured a short distance away at a cost at the mines of about \$1.00 per ton for run of mine coal, the power cost is about the same with one system as with the other. The cost of power house, labor, water, waste, oil, stores, etc., balances the saving in the cost of coal. Where the coal cost is higher, the coal saving in itself may be sufficient to compel electrification on economic grounds. In California, for instance, where coal is \$8.00 or \$9.00 per ton, electrical working may be adopted solely because of the coal saving; the large saving to be effected because of this coal saving admits of a small traffic density there, and justifies electrification more than in the Middle West.

There are also large savings to be expected by electrical working from a lessened repair bill. A good many of the derangements which come to electrical motor vehicles may be repaired where they occur out on the road, instead of requiring a trip to the roundhouse, when there is not only the repairs to be paid for, but the lost time from service of the locomotive in making the trip as well. The tendency of electric motor vehicles is towards relative freedom from

the aggregation of small troubles which are responsible for a good deal of the repair bills of the steam locomotive, and these small derangements will keep small, whereas in a steam locomotive they magnify themselves; they cannot be attended to on the run and the result is that at the end of the run they have grown to a derangement requiring a trip to the repair shop. Take the case, for instance, of a badly packed stuffing box; in an attempt to stop it from blowing the engineer jumps down from the cab at the station, twists up a couple of turns with a wrench, gets the packing jammed or too tight and comes in with a cut rod. Repairs would also be cheapened because of the greater standardization of electrical parts, and because a good many of such repair parts permit of easy installation without fitting. As to standardization, everybody believes it to be extremely desirable and everyone may be counted upon to work towards standardization and to secure it in a measure. At the same time there has been an effort to secure standardization of steam locomotive types which has not been altogether successful. There is tendency now to standardize electrical types which may be about equally successful. The variations, though, may be expected to be merely ones of detail. However, the developments are such, that the fitting which will be required will be small. A great many electrical parts can be transferred directly from one machine to another, whereas with any steam engine an attempt to transfer a part from one machine to another leads to tedious and expensive fitting, and in the fitting of new parts there is usually a good deal of dismanteling to be done in addition to the fitting, all of which runs up repair bills. There are fewer danger points for derangements on the individual electric locomotive than on the steam locomotive, that is, there are fewer points the derangement of which disables the machine. The uniform load and the even torque on the motors tends to reduce strains and failure. The result is, we may predict, a maintenance charge of about 3 cents a mile for electrical locomotives against 8 to 11 cents for steam ones and of about $1\frac{1}{4}$ cents per car mile for multiple unit suburban cars.

The electrical working will cut out a great deal of the dead time, will shut off the consumption of power, or rather the consumption of coal at the individual motor during stops, by its higher speed will reduce the cost of train labor per train mile, will reduce somewhat the shrinkage of coal between the coal pile and the grate bars, will permit the use of the cheapest kind of coal, remove a great many of the roundhouse expenses and remove altogether the expense of keeping up water stations; will allow the substitution of cheaper roundhouse labor and reduce the fixed charges for the plant for the handling of terminal rolling stock. With electricity, trains can be operated at a less weight per passenger or a less weight per horse power at the draw bar, than steam locomotives. This will effect some saving, since the cost of transportation varies in

some degree with train weight. In the case of an electric locomotive of the larger size, a 95 ton electrical locomotive will more than do the work of an 160 ton steam locomotive and we thus save on locomotive hauled trains, 60 to 70 tons on a 300 to 600 ton passenger train. In the case of suburban trains operated by multiple unit motor cars, the weight of the locomotive is replaced by a much smaller weight for the motor equipment and here on a 200 ton train we are in a position to save 30 to 40 tons. With electric and steam locomotives of equal power, the entire weight of the tender is saved and in some cases, part of the weight of the locomotive, in addition to which the entire weight, or a large portion of the weight of the electrical locomotive, may be driver borne. Electrical operation allows a higher mileage capacity of equipment so that although the electric equipment costs somewhat more than the steam equipment, the additional mileage power may serve in a measure to bring down the fixed charge for electrical motive equipment per train mile closer to that for the steam trains than is apparent on first sight. It is contended that economical operation of trains is based upon and secured by making the train weights as heavy as possible. With the choice afforded us of as many motors as we desire on a train, there is practically no limit to the motive power with which we can equip a train and consequently no limit, except the capacity of the draw bars, of the trainload which can be handled under electrical working. Some lessening in the track maintenance may be expected, although whether appreciable or not is somewhat in question, and there will be lessened derangements to traffic because of the more facile control over an electrical train. These derangements of traffic are doubly expensive. They are an expense because the train labor, fuel consumption and other charges per mile go on with a steam train and they result in a tangible money loss in the shape of fares, in the case of a suburban service. In an individual case passengers finding the service interrupted will resort to alternative street car or other routes offered them. If the derangements become frequent they will get out of the habit altogether of patronizing the line and a permanent loss of traffic will ensue. The steam locomotive is exposed to additional derangements during cold weather because the steaming capacity of the boiler is reduced in time of intense cold, and cylinder and steam pipe condensation is largely increased. The last year of suburban operation under steam on the New York Central R. R. terminal brought forth incessant protest during the cold weather on the part of its patrons. On some days there was hardly a train which was not more than a minute or more late and some of them 15 to 30 minutes late, the delays being ascribed to reduced steaming power in the locomotives.

The third of the general reasons we have advanced for terminal electrification is, perhaps, the one which at the present time will receive the greatest consideration from railway officials; that is, ability to attract more traffic or to get a greater train movement over

terminal trackage. The attractiveness to the public of an electrically operated terminal on through service permits of good advertising features in drawing this class of traffic to the railroad. In suburban traffic it should prove a feature which will be capable of bringing in excellent financial returns to a railroad, by turning the suburban service into an adjunct of the local transportation service of the community. The railway's local patronage may be divided into two classes, those who dwell in close proximity to the railroad line and those in comparative isolation from attractive competing lines. Except for the outlying suburban territory, the bulk of the suburban patronage lies in the latter class and the tendency will be for the latter to be encroached upon, since improved transportation systems are being continually extended into the suburbs. If a person can get an electric surface car down town in a reasonable length of time, particularly if he can get such car without reference to a time table, he will give his patronage to the surface company and the railroad company must either offer equally good or more attractive service, in order to get a paying share of the traffic. This has been recognized particularly by the British railroads. In many of the English cities, a large part of the local transportation field is occupied by the suburban service of the steam railroads. The communities in general are much more dependent upon steam suburban trains than they are in the United States. The movement toward electrical equipment of surface car lines, and in particular the building of interurban lines, has been much slower in Great Britain than in the United States. In consequence the British railway managers have been able to see a lesson in the United States in the building of numerous interurban lines, and in consequence have set about to bring their facilities to such a high standard that the building of competing lines in their territory would not be undertaken. As a result several of them have electrified their suburban service and put on a fast and frequent schedule of trains made up of multiple unit cars. They have met with a greater response from the public because of their improved service, and have met with financial returns because, in the first place, they have secured a large increase in their patronage, and in the second place, economies in working which enabled them to haul the individual passenger at a lower, yet a profitable rate.

The use of higher speeds on suburban service does not appear to be economy at first. As a matter of fact, the increased power consumption due to high acceleration adopted—(for the accepted principle of working is to develop a high initial speed and then coast on part of the run)—is only one factor with several others in making up the total cost per train mile; the saving in these by higher speeds will offset the increased cost of the power, the total power charge being somewhere around 10%; thus the train labor per train mile decreases with the increased speed, as does the cleaning and other charges which amount to so much per day rather

than so much per mile. The higher speed may even result in cheaper working until we consider the interest on the extra investment for the higher power equipment, the extra cost of feeders, etc., when the saving may be offset. In turn the interest charges on certain parts of the investment, which will be a constant gross amount over a somewhat wide variation in the size of plant provided, will be spread over a greater mileage and the charge per mile consequently brought down; thus, for instance, the investment in car sheds, in power house building and terminal platforms will be rendered more efficient. The demand on steam railroad suburban operation is for the provision of stops at shorter and shorter intervals as the patronage increases. This requires quick acceleration in order to get an acceptable mean running speed. For this character of service, electrical equipment is eminently adopted because of the rapid acceleration it provides and because of the ready control afforded over the motive power, together with the characteristic of the electric motor that it holds its efficiency over a wider range of speed than does a steam engine. The absolute elasticity of multiple unit equipment is highly desirable. During the middle of the day some method, in a suburban service, of providing numerous light trains instead of a few heavy ones is desirable. With multiple unit equipment, instead of six car trains at half hour intervals, we may run two car trains at ten minute intervals, with only a slightly higher cost. And during the rush hours, when many trains must pass over the tracks, the provision of heavy trains will not reduce the running speed at the very time when it is most needed to keep traffic open, as is the case when we overburden suburban locomotives with heavy trains. From the point of view of the railroad management, the substitution of numerous light trains for occasional heavy ones has its advantages in that the added convenience to the public will cause the coaches to be generally filled instead of only partially, as is too often the case in present steam suburban trains.

The utilization of the suburban tracks to their full value as local transportation agents is very desirable to the community. The people want to use the suburbs as dwelling places, and it is to the interest of the municipality to have this come about, since it increases the taxable area. It must become increasingly difficult to dwell close to our places of business. Any city must necessarily have a large congested business district. For business convenience the offices of large business firms and those who deal with them must be close together, housed in tall buildings. From this district the population must be distributed. With street traffic growing more intense every day, the distance at which a man may live and come down to his work on the surface car lines in an acceptable period of time must grow less every day. Further increase in possible maximum speed can avail the surface cars little since their progress is limited by the frequency of stops and the street obstructions—both of which are getting worse. To provide express service to the out-

lying district a route must be chosen clear of the streets—that is an elevated railroad, a subway, or a steam railroad right of way already elevated clear of the streets. Elevated railways and subways are very expensive to construct and must run through populous districts in order to earn carrying charges upon the investment. The steam railroad, however, has already a traffic developed which will carry it, and, if electrically equipped, is able to afford local transportation to the community equal to the best a subway can afford, for the new investment in the mere equipment it would be necessary to provide for a subway. A more desirable load on the power station would be assured than the operation of an independent road would offer since the movement of through trains and the switching on the terminal would be the greatest outside the suburban rush hours and would tend to relieve the severity of the peak load upon the power house.

When we come to the question of capacity we find that it is here electrification is most likely to appeal to those who direct the policy of railroads. Terminal property is becoming increasingly expensive. As its use increases the efficiency of many of its individual parts must decrease. Thus, as a terminal becomes busy, junction points, crossovers, turnouts, and other disturbers of traffic multiply. The tendency to heavily load the freight trains reduces the speed of these trains and these slow trains limit the movement of others. In the opening of a new terminal, if the adoption of a particular kind of motive power will allow us to provide for less outlay in land for tracks to do the required work, it is an advantage, as it is with a crowded terminal, to allow us to gain desired additional movement without providing additional trackage. Electrification provides a system of working which gives efficient control, quick acceleration, allows us to get past disturbing points with a minimum of delay, does away with a lot of dead time for equipment, makes less switching, gives a higher speed and a lessened time of passage over busy tracks, allows of almost any train load being handled without much loss in speed, and, in general, allows us to work a terminal at about double the capacity it possesses under steam operation.

With the enhanced property values of terminals, their crowding of their use for car storage purposes must cease. For through freight, common transfer yards must be provided outside the cities and the freight there transferred, instead of burdening the terminal tracks. The use of valuable downtown property exclusively for the storage of empty freight cars, and eventually of even empty passenger equipment must cease. The ground is too valuable not to be bringing in a rental. The same is true of using terminal freight houses, as at present constructed for freight storage. There will be a demand that they be worked more intensively. Trains must be brought in, quickly unloaded, the cars loaded again and sent out of the city to the outside yards. Practically this means small trains over the terminal. Here again electrification recommends itself

with its economical handling of the small train load and its ability to get trains over the tracks in a hurry. And with the use of electric locomotives about the terminal warehouses, it becomes possible to use them not only for receiving and delivering freight, to build them many stories in height—even to carry them on columns and cover the tracks with them—and utilize the upper stories as warehouses on a plan similar to the co-operative warehouse scheme adopted at Nashville and one or two other places. The dealer in bulk merchandise may then be saved the expense of 50 cents to \$1.00 per ton of teaming his goods across town—leaving the merchandise in the storage warehouse until sold and delivering it to the railroad on the ground floor for shipment. With the danger from fire gone and the possible damage from soot and dirt removed, the storage will commend itself to merchants. The New York Central R. R. is planning to cover its entire yard and right of way at its New York City terminal, since electrification, with large office buildings from which, due to their central location, a handsome revenue may be expected to be returned in this direction, from its electrification.

An electrified terminal also presents the opportunity (because of cheap handling of varied train weights and ready starting and stopping) of affording a local freight service analogous to the suburban passenger service. It is a problem with large retail merchants how to handle their outlying deliveries. On an electrified terminal light freight trains with a car for each suburban station could be made up a couple of times a day and run out over the line, dropping a car at each stop, and picking up the cars, on the return trip. The local wagons could meet these cars and distribute the goods through the adjacent district instead of making a long trip from the city or being worked from one or two outlying delivery stations to which goods are sent by teaming or automobile truck delivery.

Examining the terminal electrifications which have been made we find that electrifications have been decided upon for each of the three general reasons we have advanced for electrification. The New York Central electrically equipped its New York terminal because the continued operation of steam trains through the tunnel entry into the terminal was held by legislative enactment to constitute a public danger. The Paris-Orleans (on its Paris terminal) the Long Island Railroad (on a Brooklyn terminal) and the Baltimore & Ohio (on its Baltimore terminal) all electrified their terminals because of the construction of new terminals with tunnel entries in which the operation of steam locomotives, would be deemed distasteful or dangerous to passengers. The operation of steam locomotives upon these terminals was never attempted. The new Pennsylvania terminal into New York City is to be electrified for a similar reason. The New Haven and the North shore electrifications have been carried out, it was announced, to secure operating economies. To secure capacity the various tunnel electrifications, as—The Grand Trunk, The Great

Northern, the Michigan Central, and the Simplon Tunnels—have been carried out and to secure capacity is said to have been the reason why the New York Central was seeking to electrify its tunnel, prior to the compulsive action of the legislature. To gain additional patronage is the avowed purpose of several British electrifications.

The New York Central electrification of its New York terminal is the largest yet carried out. At the inception of the work, there were about 650 trains into or out of this terminal each day. The terminal station is at 42d street. Entrance thereto is by means of a four track line, partly on an elevated structure and partly within a tunnel with a sunken terminal yard at the station. The tunnel extends from 56th to 99th streets, a distance of a little over two miles. Under steam locomotive operation, the gases within the tunnel were objectionable to travelers and to dwellers in the vicinity of the ventilation shafts opening to the street above. The operation of the heavy traffic within the tunnel was dangerous, despite the provision by the railroad of the most elaborate safety devices. There had been persistent agitation upon the part of dwellers along the right of way against continuance of the nuisances (similar to the recent agitation against the Illinois Central R. R.) when public sentiment was crystallized by a serious accident within the tunnel on January 8, 1902. A legislative provision was made shortly afterward requiring the operation of trains within the tunnel, after five years, by some form of motive power which would not require combustion within the motor vehicle.

Prior to the enactment of the legislation, however, the New York Central R. R. had taken steps looking to the electrification of the terminal. The terminal was crowded. North of the Harlem, at Mott Haven, there is a junction of three lines of that railroad. The main line of the railroad is a four track line, running along the bank of the Hudson river from Albany south, and coming to Mott Haven from a westerly direction; the Harlem Division is a four track line coming from Chatham, about 130 miles north, carrying the main line traffic of the New Haven road from its junction at Woodlawn and coming into Mott Haven from a northeasterly direction; the Putman division (not electrified) lies between. The junction and the tunnel entry into New York City acted as a throttle upon the road and electrical operation, for capacity reasons, has been long mooted. With the electrification, and as a part of the terminal improvement, the terminal area has been increased 200% and the storage space about 450%.

The electrification is intended to be extended to Croton on the Hudson Division, 34 miles out and to North White Plains on the Harlem division, 24 miles distant. The part so far completed, comprises an initial zone extending over 17 miles; from the Grand Central Station to Wakefield, 13 miles, and from Mott Haven to Kingsbridge, 4 miles. In the zone there are electrified 73 miles of main track and 12 miles of yard track and sidings, or 85 miles in all.

April, 1909

The extension of the electrification is under way and eventually the whole electrification will comprise 224 miles of main track and 68 miles of other tracks, or 292 miles total. Secondary tracks and freight tracks have not yet been electrified.

Two independent power stations are provided—one on each division of the road, interconnected, and each capable of handling the entire present traffic. Each station has a present capacity of 20,000 kw.—and an eventual capacity of 30,000 kw. There are storage batteries in each substation of a capacity sufficient to carry the entire load. These batteries vary in capacity from 2,250 amperes to 4,020 amperes on a 1 hour discharge rating, depending upon the capacity of the substation. The electric current is generated by turbo-alternators, at 11,000 volts and distributed at that pressure. The transmission lines are carried partly in conduits underground, partly in conduits in the tunnel walls and partly in pipe conduits on top of the retaining walls within the city. Outside the city there is an aerial transmission line, carried on steel poles.

The substations vary in capacity from 3,000 to 4,500 kw. there being three 1,000 kw. rotaries installed in the smaller stations and three 1,500 kw. machines in the larger ones. The substations vary in distance apart, from 10 to 5 miles,—the closer spacing being at the terminal end. There is one station right at the end of the terminal. A protected underrunning third rail of the "Sprague-Wilgus" type carrying 650 volts, is installed, there are numerous sectionalizing switches for the isolation of sections of the track and circuit breakers are installed at intervals in houses erected for the purpose. To serve as a return, the track is bonded with bonds concealed under the splice plates. High frequency, alternating current, is used for operating the signals, impedance bonds being installed at the ends of the blocks to admit the passage of the return current, but to prevent the passage of the signal current.

The through trains are hauled over the terminal tracks by electric locomotives of the 2-8-2 type. Each weighs 95 tons, is 37 ft. long overall, with 27 ft. wheelbase and is equipped with 4-550 H. P. motors; the overload capacity for a short period being 3,300 H. P. The motors are bi-polar, with broad flat pole pieces; the armatures are mounted directly upon the axles and the brushes carried on the truck frames. They are designed to afford accessibility and to readily admit of repairs. The locomotives are fitted with double and multiple unit control gear.

Suburban trains are made up of multiple unit motor coaches and trailers. The cars are of steel; the motor coaches weigh 53 tons and the trailers 44½ tons, each.

The New York, New Haven & Hartford Railroad, in addition to sending its trains from Woodlawn Junction to the Grand Central Station (12 miles) over the electrified New York Central zone, has electrified its line from Woodlawn to Stamford, Conn.—a distance of 21.5 miles; the electrification extends over rather more than 100 miles

of equivalent single track. This road had previously in electrical operation several branch and secondary lines, its initial excursion into the electrical field being in 1894. This later electrification however is a trunk line electrification extending over a four track section of the New Haven, New York and Boston line.

A single phase equipment is adopted, each working conductor being suspended by triangular hangers from two stranded steel catenary messengers, the latter being carried on insulators on steel bridges spanning the tracks at 300 foot intervals. At two mile intervals are anchor bridges—heavier and more strongly braced—to which the messengers are anchored. These bridges carry current-breakers, section insulators for the contact wires, transformers for auxiliary circuits, signal semaphores, and sectionalizing switches. They are located near signal towers, the tower attendant giving the necessary care to the devices on the bridge. The entire contact line over a given track is connected in series and adjacent lines are interconnected at the strain bridges. There is, in addition, an auxiliary feeder carried on each side of the line, each feeder connected to the line at alternate anchor bridges. Thus, when a section of track is cut off from the current, a way is provided around or a way is furnished for feeding current past a heavy local demand. On curves, the spacing of bridges is slightly closer and an intermediate pole set up at the side of the track with pull-offs to the trolleys. At one of the yards bridgework is dispensed with and a single catenary construction adopted supported from a cross catenary span between poles. As originally installed the contact line was too rigid. As the shoe passed along it, pressing upward, a kink was put into the working conductor next each hanger, this leading to jumping of the shoe in subsequent passages whereupon bad arcing resulted. This has been cured by the adoption of an auxiliary contact wire underneath the main conductor and suspended from it by clips at points midway between hangers. This has given the requisite flexibility and sparkless collection results. The auxiliary contact wire is an iron, figure of 8 wire, cheap in first cost and cheap to replace. It has an advantage in addition to giving sparkless collection, in that the wear is transferred to it from the more expensive copper conductor, it is readily replaced when torn down, and the accidents are transferred from the main conductor (where they would interrupt traffic) to the auxiliary conductor which may remain torn down for several days, the trains being supplied with current from the main conductor meanwhile.

It is the intention of the New Haven road, to eventually electrify its entire line from New York to Boston. Consequently this section has been installed with an eye to its eventual function and the power house located at one end of the line instead of at its center. Single phase current is taken from 3 phase turbo-generators at the Cos Cob power house and fed to the line at 11,000 volts. There are no substations.

April, 1909

All trains are hauled by electric locomotives, although motor cars are to be used for branch lines. The locomotives are each equipped with four 250 H. P. single phase motors, the armatures suspended from the drivers by a quill suspension, the driving pins held centrally and the torque transmitted by offset special springs in pockets in the drive wheels. The field and field frame are split horizontally and attached to the frame of the truck by suspension bars and springs. The locomotives are fitted to work on direct current in the New York Central zone and single phase current on the New Haven—consequently their interior construction is somewhat complicated.

It is the avowed intention of the New Haven road to work its entire line from Boston to New York by electricity. This railroad is also gaining control of the street railway systems throughout its territory and working them in unity with the railroad. These systems will act as feeders for the road and their power houses, with the provision of the necessary additional units, will be able to supply the main line with current at different points along its route. In addition, a combination of the electrified steam road and the local street car lines, will establish a comprehensive interurban system. Mr. Mellen, the President of the New Haven road, advocates running the local street cars of adjacent towns over the electrified steam road. Thus the resident of Stamford, for instance, will be able to take a car at his door, running over the local streets to the railroads, thence along it to New Haven, and then by way of the streets in New Haven, to the door of the store where he wishes to do his shopping.

The Long Island Railroad has an electrified terminal in Brooklyn in addition to one worked by steam locomotives. The terminal improvements at the Atlantic and Flatbush avenue terminal involved the use of an underground terminal and a tunnel entry. The conditions are similar to New York, although the trains leaving the terminal are entirely suburban. Legislative enactment required working by a form of motor not requiring combustion on the motor vehicle—hence, electrification. The electrified zone comprises about 100 miles of track. The route is partly in a tunnel, partly on an embankment or structural steel elevation, partly on the level, passing through a number of towns with crossings at grade. There are lines to Hempstead and Valley Stream and a line to Rockaway Beach which carries heavy excursion crowds. The line is generally double track, though partly four track.

Power is generated at Long Island City. Instead of being at the electrical center of gravity this power house is not even on the electrified section. The reason for the location is that the power house will be extended to provide power for the projected electrification of the Pennsylvania's New York terminal, and it should preferably be located convenient to the latter. (The Long Island Railroad is a Pennsylvania property.) There are installed three 5,500 kw., 6,600 volt 3 phase alternators in use by the Long Island. The power house is built to contain six such units and land owned by the com-

pany will permit of extending the power house lengthwise to hold seven more—a total of thirteen. The load variation is now somewhat severe; with the loads of the Pennsylvania and the Long Island carried on the same power house the load will be more even.

The current is transmitted from the power house by a line, partly underground part'y aerial, to Woodhaven Junction, where the Rockaway Beach line leaves the main line. At Woodhaven Junction is a substation and a distributing station, whence the high tension current is distributed to the other substations. The substations vary in capacity from 4,500 kw. to 2,000 kw. 1,500 kw. rotaries are installed at the larger substations, 1,000 kw. rotaries at the smaller ones. The foundations for the 1,000 kw. rotaries will take the 1,500 kw. ones as well, the base plates being built to accommodate this. As the smaller substations grow unequal to the demands 1,500 kw. rotaries can be substituted for the 1,000 kw. ones, and the latter removed to new substations on extensions of the electrification. At Hammel substation, near Rockaway Beach, where holiday loads are high and a submarine crossing renders the interruption of the transmission line probable, there is a large storage battery. Portable substations are provided to help out abnormally loaded stationary ones or to take care of extensions pending the provision of permanent substations.

A 600 volt 3d rail, direct current installation is provided. The rail is protected by a board shelf extending over its top, the board being held by clamps to the rail. Between substations the rails form continuous conductors, no feeders being provided. Past grade crossings the rail is interrupted, the continuity of the circuit being kept by providing jumpers between the rail ends—the jumpers passing under the streets in drain tiles filled with pitch. Where turn-outs and special isolated sections of rail occur the earlier plans provided for cables from these sections to switch houses at the side of the track to which a line was led from the nearest substation. Present practice is to tie such rails into the rails paralleling the main line of track with switch boxes interposed.

Trains are hauled entirely by multiple unit motor coaches. Motor coaches and trailers make up the trains in the proportion of about two to one. Two electrical locomotives were in use a short while. These were experimental locomotives bought by the Pennsylvania for trial in its experiments looking to the electrification of its New York terminal. They were afterwards sent to the West Jersey and Seashore—another Pennsylvania property.

The West Jersey and Seashore is properly not a terminal electrification. It extends from Camden, New Jersey (across from Philadelphia), to Atlantic City—a distance of about 65 miles. It was probably electrified to prevent the building of competing interurbans. There are about 150 miles of track electrified. Except for an overhead trolley through some of the towns, a third rail direct current 600 volt equipment has been provided; the same type of

rail protection adopted as was used for the Long Island. Multiple unit motor car trains are used.

The Pennsylvania is building a new terminal in the heart of Manhattan Island, New York City. Their route from Bergen Hill on the New Jersey side, under Jersey City, under the Hudson River, across Manhattan Island into and through their terminal, under the East River and Long Island City to their storage yard lies in tunnels; some four track, some three track, and largely double track. Electrical operation is the only kind to be considered in such a case. Contracts were recently let for the electrical equipment. It is stated that the system to be used is not yet specified but it is presumed that it will be single phase.

The Baltimore & Ohio was the first terminal electrification to be undertaken in the world. It was electrically equipped in 1895. The entry of this road into Baltimore was formerly by ferry, and the better entry of the Pennsylvania gave them an hour's advantage in running time between New York and Washington. To secure direct entry the B. & O. laid out a new route and constructed the same largely in tunnel. To save the passengers from the smoke nuisance electrical working was resorted to. A section extending over 3.4 miles of double track was electrified, a direct current equipment being provided. The service is hardly a terminal service but really a pusher service on a grade through tunnels. The east bound trains retain the steam locomotives, idle, at the head of the train the electric locomotives pushing the train through the tunnels stopping at two stations en route. All west bound trains drift through the tunnel down grade and the electric locomotives finishing an east bound run drift back light. There are 300 to 400 trains per day. Originally an overhead conductor was installed, two suspended Z bars forming a trough in which a skate on the end of a diamond pantograph slid and collected current from the inside surface of the webs of the Z's. The corrosive gases from the locomotives rapidly deteriorated this structure and it was replaced by a third rail in hope of cheaper maintenance. This is protected in the tunnel by a plank at its side set on edge and projecting above it. It is thus hard for a track laborer to step upon it or to pry a crowbar or tamping iron into contact with it. At Mt. Royal Station the rail is interrupted, the trains floating over the gap. At the other station the platform planking is carried over the rail to leave only a narrow crack through which the web of the collector shoe can pass. At a crossover in the tunnel a movable third rail is installed. To guard against locomotive stalling, some conductor had to be placed within reach. A rail at the standard height would block the track. So the movable rail is installed, arranged to be lifted by levers from the adjacent signal tower should its use ever be required. There being only one such place it was cheaper to install this device than to put in an overhead conductor and equip each locomotive with a pantograph collector seldom, if ever, to be used.

The North Shore has a suburban line running from Sansalito, just across the harbor from San Francisco, along a promontory. It was originally a narrow gauge line extending north to Cazadero, 87 miles. It has since been extended. At its southern end are suburban towns and adjacent is Mt. Tamalpais, an excursion point. In 1902 the gauge was broadened and the lower end electrified. The electrification extends over 13.69 route miles of double track with spurs and branches. A third rail direct current installation has been adopted, multiple unit motor cars being provided. Current is purchased from the Bay Counties Power Co., controlling a number of hydraulic power developments in that part of the country. Current is delivered at 50,000 volts and stepped down to 4,500 for transmission to substations. An auxiliary steam plant is provided. The right of way through towns is fenced to prevent trespass. Outside the towns there is no protection. Within the towns reconstructed granite insulators are used for the third rail. Outside creosoted wood blocks are used; a block, sawn from a cross tie being spiked at the ends to the ends of opposite cross ties belonging to the two tracks and both contact rails being carried between the tracks on one insulator. On single track sections a block from a cross tie is bedded in the ground opposite the end of a tie and the insulator spiked to this block and to the end of the cross tie.

The Southern Pacific has under construction the electrification of its suburban lines out of Oakland across the harbor from San Francisco. Entry into San Francisco from the east is by ferry across the harbor from a long mole into the harbor from Oakland, at the end of which is a terminal for transcontinental trains. A similar mole at Alameda is used to accommodate a large suburban traffic between San Francisco and suburban towns on the mainland among which are Oakland, Berkeley and San Jose. This is handled by steam and is said to be the heaviest steam suburban traffic in the country next to the Illinois Central and the Northwestern. Coal is high on the Pacific Coast and its saving is worth while. In addition the Southern Pacific has suffered competition from the San Francisco, Oakland and San Jose Valley or so-called "Key Route"—a high speed interurban road built in 1903 and catering to the same class as the Southern Pacific. About 50 miles of track are to be electrified, a 1,200 volt direct current overhead trolley being adopted.

The British terminal electrifications concern themselves principally with the suburban traffic. Suburban traffic in Great Britain is more important than in the United States, many communities relying upon steam suburban trains for the greater part of their local transportation. Take the case of London. Out of 8,000 trains per day entering the city, but 500 are long distance trains. As we have already said the building of electric interurbans is backward and the railroad managers are preventing the construction of these competitors by electrifying their suburban lines. In addition the cost of conducting this traffic has risen 25 per cent in the last decade, while

the receipts have remained stationary. Consequently it is necessary to attract more traffic in order to pay dividends.

The first British electrification of consequence was that of the "Inner Circle." For years the business section of London has been served by an enclosing loop of railroad, partly in tunnels, partly in open cutting. This loop is about 13 miles around with diverging connections and is jointly owned and operated by two companies. It was built to connect all the railway stations, the plan being for the suburban trains entering the stations to run around the loop delivering passengers to the nearest point on the loop, and within walking distance of their business. The central part of the city was left without means of transportation other than cabs and omnibuses—latterly, tube lines have been built transversing the district. As a means of local transportation the "Inner Circle" has not altogether met expectations—for one thing distances from the loop to its center are too great. For years trains on this line were operated by steam locomotives and the gases within the tunnel were very obnoxious. Beginning in 1901, its electrification was carried out. A third rail direct current installation was provided with multiple unit trains.

In 1907 there was opened to traffic the electrical service on the Great Western Railway's Hammersmith and City branch. This is a suburban line delivering trains to the Inner Circle, and its electrification was determined upon so that its trains might proceed intact over the "Inner Circle." Four route miles of double track was electrically equipped to correspond with the Inner Circle equipment.

The London & Southwestern, in order to deliver its passengers to the center of the city, built an electrically equipped tube line two miles long from its Waterloo Station to the Bank of England, using the same as an adjunct to its suburban service. A similar tube line with a local traffic, however, known as the Great Northern and City was fathered by the Great Northern Railway. As originally planned, the suburban trains of the latter were to enter the tubes upon reaching the city and run within them. A 50-foot difference in grades where the connection was to have been made prevented a physical connection and the scheme was abandoned, the tube being operated independently.

The London, Brighton & South Coast electrified a four mile stretch inside London between Battersea Park and Peckham Rye, as an experiment. This was an unimportant cross line between two main lines. Successful the electrification was extended along the main lines into the terminal at each end, giving a U shaped electrified route, extending over 12 route miles of double track between London Bridge and Victoria Station. A single phase installation was adopted, the motors being of the repulsion type.

In 1902 the North Eastern Railway carried out the electrification of its suburban lines out of New Castle. The principal traffic was between New Castle and Tynemouth, 8 miles. In connection therewith an entirely new electrically equipped line was built between

Gosforth and Ponteland. The electrification extends over 37 miles of single, double and four track line, and over a total of 82 track miles. A standard 3d rail direct current installation was made. Power is purchased locally. Through trains are still operated by steam locomotives. The Quayside branch, a freight line passing by wharves and industrial plants was electrified, and freight on this line is handled with electric locomotives. The freight yard is provided with an overhead trolley—span wire construction. The financial returns have been good and the operation of this electrification excellent. The purpose of the electrification was to hold the suburban traffic.

The Lancashire and Yorkshire has electrified its suburban lines out of Liverpool. The suburban service carried by this line is almost identical with that of the Illinois Central. The bulk of the express trains run to Southport, 18½ miles distant, with occasional trains beyond. Local trains run mostly to Hall Road, 7½ miles distant. Stations are about ½ mile apart—the spacing is greater in the outlying territory. The road is practically level, without severe curves, skirts the seacoast at first, then strikes inland. Excluding lateral branches at the time of the electrification about the same number of suburban trains were run as the Illinois Central now runs. A third rail direct current installation was adopted with multiple unit trains. A physical connection has been made with the Liverpool Elevated, and the latter's trains run out to the suburbs on the Lancashire and Yorkshire.

In Italy the Mediterranean Route has electrified its suburban terminal on the Milan-Varese-Porto Ceresio line, adopting a direct current equipment with third rail—trains of one motor car and several trailers later replaced by multiple unit trains. The initial equipment was over about 80 miles of track—it has been extended from time to time.

The electrification now extends to a maximum distance of 30 miles. The traffic is said to be the most dense in Italy. It was electrified in 1901 as a part of an experiment by the Italian government looking to a general electrification of the Italian roads. Direct current working was applied to this terminal, while 3 phase equipment was applied to the Vattellina over a stretch of 67 miles—the latter being a road through a sparsely populated district chosen to represent the other extreme.

The Paris-Orleans Railroad in 1900 inaugurated electrical service into its Paris terminal. This road is one of the most important in France. To get closer to the center of Paris a new terminal station was built at the Quai d'Orsay and connected with the old Austerlitz terminal by a tunnel, the station tracks being below street level in addition. The station has 16 tracks and is used daily by about 600 trains. As steam locomotive working would be offensive the new terminal was electrically equipped with a third rail and direct current equipment. At first the electrification covered only the

2½ mile section between the stations. Later it was extended to Juvisy, 14 miles distant, in order to secure expected profits from suburban traffic, to spread the fixed charges over a greater train mileage, and to secure a more even load at the power house. With the extension, the expected decrease in train mile costs has been utilized. Through trains are hauled by electric locomotives. Multiple unit trains are used for the suburban service. Freight does not go through the tunnel and is handled by steam locomotives. A few fast mail and limited trains are run into the terminal by steam.

The French Western operates an electrified line for its Paris Versailles suburban service. This line runs through a tunnel for a little over two miles and has an underground terminal station. The electrified line extends over 11 route miles. Third rail direct current equipment has been provided, the trains made up of a motor coach at front and rear ends with a variable number of trailers between.

The latest terminal electrification is that at Melbourne which has just been decided upon. There the suburban lines are relatively very important. They comprise 298 miles of track out of a total of 4,000 in the colony, and the suburban train mileage is 40% of the total train mileage. The desirability of the electrification has been under investigation during the past two years, and the decision recently announced. The electrification is planned to be carried out over one of three zones—varying from about a quarter of the total mileage to the entire suburban mileage. After searching the field the choice narrowed to single phase equipment, or 800 volt 3d rail direct current equipment, the decision being made for the latter after due consideration. The estimated savings under electrical working are not quite sufficient to balance the additional fixed charges and interest charges, but are within 10% of enough. The added patronage to be expected, it is believed, will cause a net gain.

Coming to Chicago, everyone is interested in the Illinois Central. The railroad operates a suburban service of 262 trains per day to Flossmoor, 25 miles distant, and to intermediate points, to Blue Island, 19 miles distant, and to So. Chicago, 12.92 miles distant, the two latter being on lateral branches. Comparatively few trains on the Randolph St.-Flossmoor trunk go to the end of the zone. Most of the trains to the outlying stations are express trains, while a strictly local service is maintained as far as Woodlawn, 8 miles distant. There are in all 72 locals and 59 express trains each way, per day, on week days, and 47 locals each way on Sundays. In addition the terminal trackage handles the large through passenger and freight traffic of the Illinois Central, together with that of the Michigan Central, Wisconsin Central, Big Four, and Chicago, Cincinnati & Louisville. There are scheduled, daily, 60 through passenger and freight trains—the actual number exceeds this. There are over the terminal zone each day 3,428 scheduled suburban train miles, 1,054 scheduled passenger train miles, 607 scheduled freight

train miles. A 24-hour observation disclosed 6,435.5 train miles of observed and estimated trains, 2,700,000 observed and estimated ton miles.

At 6:10 P. M. occurs the maximum of 34 trains simultaneously upon the line—there being a maximum of 115 suburban coaches in these trains. The maximum load upon the power house under electrical operation is estimated at 12,000 kw. Not including a power house but including substations we have estimated that an electrical equipment (with a 3d rail contact, multiple unit equipment for the present suburban coaches, and electric locomotives for through trains), could be provided for about \$4,000,000. We estimate that the savings to be expected will offset the fixed charges on the investment and pay acceptable income charges. It is to be expected that with electrification the Illinois Central will put on more and faster suburban trains, leading to increased patronage and larger earnings to afford a net gain in income.

The Illinois Central has in hand an extended inquiry into the possibilities of electrification. What definite action they will take it is difficult to predict. We do not believe that definite plans have been adopted. The railroad has, however, announced its intention to electrify, it is going ahead with its investigation in good faith, and it is to be, therefore, expected that they will electrify. The form their plans will take may be awaited with interest.

DISCUSSION.

December 2, 1908.

President Loweth: Mr. Evans' paper has opened up to my mind quite a prolific subject for discussion, and I have no doubt that there are many gentlemen here who would like to ask some questions and perhaps discuss the paper. The opportunity is now before you for such questions or discussion.

Mr. P. Junkersfeld, M.W.S.E: Mr. Evans' paper is so very complete and thorough that there seems to be little room for further remarks without danger of repetition. However, even in the face of such danger, the subject might be discussed under three headings—(1) Just and reasonable demands of the public; (2) Decreased expense of operation; (3) Possible additional revenue.

Under "just and reasonable demands of the public" we must consider the two large bodies of people interested; *first*, the passenger patrons of the road and people who live in the terminal city; *second*, the stockholders of the railroad company, the employees of the railroad company and the employees of the various manufacturing companies who furnished the equipment, all three being dependent on the net earnings of the road. These two large bodies are often in conflict at the start, but usually there is a happy medium—a fair middle ground—that can be finally found. In this day and age the

April, 1909

most important thing is that neither side should expect to have the cake and eat it, too.

Under "decreased expense of operation" Mr. Evans has pointed out clearly, that as far as maintenance and repairs are concerned, there is no question about there being considerable saving; but where coal is as cheap as it is in Chicago it is difficult to show any large net saving. That brings up the point that the fixed charges are a big part of the expense, and we have to consider what can be done to reduce those fixed charges. In England, a body that corresponds to our Interstate Commerce Commission is considering the question of the regulation of the leaving time of through trains. For instance, in London several of the competing roads will each run a train leaving at the same hour for Glasgow, to Edinburgh, etc. Similarly, in Chicago, one road competing for St. Louis traffic will put on a train at a certain hour and the others will all follow suit. In England, the idea is that they will decrease expenses which will eventually revert back to the benefit of the public. A scheme like that would be a much better load factor for the electric locomotive and power equipment.

Another thing which would improve the load factor would be the forming, perhaps, of terminal associations, or at least the operation of those electrical equipments centering in one depot under a single management. If the several roads would get together and have an arrangement whereby the equipments could be kept more constantly in use instead of lying idle, much benefit would result. A still further step would be the consummation of a plan as proposed by Mr. Delano, which, as you will remember, contemplated placing back from the center of the city a terminal for quite a number of railroads entering Chicago; have them all build their terminals side by side at Twelfth Street. That would make, probably, a still further improved load factor, for the electric equipment and also on the power, whether they manufactured the power themselves or purchased it.

In regard to the third point—"possible additional revenue"—when the possible large increase of suburban traffic due to the constantly increasing tendency of moving into the suburbs and into the country is taken into consideration it is an important item, and increased revenue from suburban traffic would doubtless, by itself in a few years, go a long way toward paying for this additional expense due to electrification.

I think no one who has looked into the New York Central R. R. electrification, where the conditions are similar to those here in Chicago (in fact the Illinois Central R. R. conditions are probably more favorable for electrification than the New York Central), can doubt that the time has come when the Illinois Central R. R. should electrify, with benefit to both of the two large bodies at interest—the public and the patrons of the road, and the second body, recently termed in a discussion as a "constituency without representation;" that is to say, the public would be given its just dues, and with some

profit as well to the company. I think both these large parties can be satisfied, if the matter is worked out properly, as I understand it is being done.

Mr. E. N. Lake, M.W.S.E.: I was talking with a steam railroad engineer some months ago—and I would like to say, by way of explanation, that he is not a member of the Western Society of Engineers and is not connected with any steam railroad running out of Chicago.—Among other things, he said: “I do not believe this business of “electrolyzing” railways is going to be at all practical.” The first opportunity I had I looked up the definition of this word “electrolyzing,” thinking that I might have overlooked something in the application of electrical terms, and found that it meant the dissociation of elements by the application of electricity. It has occurred to me that perhaps there are a large number of steam railroad engineers—I mean, of course, those in the remote districts—who look upon electrification as a dissociation or disintegration of all of the essential elements of a railroad. As a matter of fact, practically the only item of equipment that is affected by electrification is the locomotive, which is replaced by three elements, viz., a generating equipment, a distribution system and a motive system.

By reference to the special reports made by the Census Bureau, and by making a few figures, it will be found that the locomotive investment of all the railways of this country is only about 5% of the total valuation of their operating properties, so that the element that is affected by electrification is in value only a small percentage of the total value of the railroad properties.

Some months ago Mr. Wilgus presented before the American Society of Civil Engineers some results of the operation of the New York Central R. R. As I remember those figures, he stated that the actual effective work which could be secured from an electrical locomotive was about 25% more than from a steam locomotive. If the system is large enough, and if the runs are so arranged that this additional work can be taken proper advantage of, it means that with a system requiring 50 steam locomotives, 40 electric locomotives will do the work. I made some figures here a moment ago to indicate what that would mean by way of savings. The steam locomotives of the New York Central R. R. were given at \$15,000 each, and 50 of them would cost \$750,000. The electric locomotives cost \$30,000 each, and 40 of them represent an investment of \$1,200,000. The annual charges against these two styles of locomotives, as given by Mr. Wilgus, including interest, depreciation, repairs, etc., were, as I remember the figures; for a steam locomotive, \$4,500.00, or 30% of the first cost of the locomotive; for an electric locomotive, \$3,700.00 or 12½% of the first cost of the locomotive. On the basis of this equipment of 50 steam and 40 electric locomotives, I find that there is an annual saving shown of \$77,000, which will pay approximately 12.8% upon the difference in cost between 40 steam and 40 electric locomotives, or

17.1% or, the difference in cost between 50 steam and 40 electric locomotives.

One other thought comes to me in this connection, and that is, that we have in the East two systems in operation—systems which are fundamentally different and which are manufactured by competing companies; and we have here in the West, or will have soon, two completed tunnel equipments which are likewise furnished by competing companies. I think it is especially fortunate that there is this competition in this matter of the development of electrification equipments. It means the same thing that competition has meant in the matter of steam locomotives; it means that each manufacturer is going to develop his apparatus and equipment to the highest possible state of perfection. One who purchases steam locomotives from any of the manufacturers of standard equipment at the present time, is sure of getting a perfectly workable and practical piece of apparatus which represents a value commensurate with the investment he puts into it, and I think that with the competition which we now have this is true, and will always be true of the two systems of electrification which are now being tried out.

Mr. James Lyman, M.W.S.E.: A superficial consideration of the electrification of large steam railway terminals, might give the impression that the proposition is largely experimental. Mr. Evans' discussion of the subject this evening, showing what has been actually done in this country and abroad in electrifying certain sections of steam railroads and their terminals, is evidence that the proposition has in a large measure passed through the experimental stage.

Indeed it may be stated that electric locomotives for handling through trains and electric equipment for suburban cars are as thoroughly standardized today for a given type, as our steam locomotives.

The New York Central R. R. has 34 electric locomotives and a large number of suburban car equipments. After a year and a half of service, this company has ordered 12 more locomotives, identical with the original locomotive furnished in every respect, with the exception of a slight modification in the trucks. Any additions to the suburban car equipments would also be identical with those previously furnished.

The Interborough Rapid Transit Co. have a standard equipment on all their subway cars and a standard equipment on all their electric cars. The same is true of the principal elevated and heavy surface electric railroads, in Boston, Philadelphia, Chicago, Baltimore and other cities.

The electric equipment for this service or for the heavy steam railway service is simpler in design than the steam locomotives.

Reference has been made to the increased cost of the electric locomotive over the steam locomotive. It is true the cost per locomotive is about double. From actual experience, however, the electric locomotive has the following advantages over the steam locomotive of

equal draw-bar pull, which fully compensates for the additional cost,

1st: For handling through trains—

About 25% greater capacity—

25% more time available for service—

50% less total weight.

2nd: For switching purposes, due to higher acceleration and more perfect control, also more time available on tracks, it can perform about 100% more movements, which means 100% more work performed than a steam locomotive of equal draw-bar capacity.

The ability of a locomotive to move a train depends on draw-bar pull. It is common practice to rate steam locomotives according to their draw-bar pull, the locomotives being designed for a certain speed suitable for express or freight service. For continuous service on either work, as hauling through trains, the capacity of the steam locomotive is limited by the capacity of the boiler. The electric locomotive has no boiler limitations and can accelerate to its maximum speed more rapidly and maintain a uniformly higher speed than the steam locomotive of the same general rating.

In a number of instances electric locomotives used for freight service have handled trains at a speed of double the scheduled speed performed by the steam locomotives they replaced.

We are indebted to Mr. Evans for an exceedingly clear, concise and interesting paper, and I move you, Mr. President, a vote of thanks to him.

FURTHER DISCUSSION, DECEMBER 11, 1908.

Meeting of the Electric Section.

Mr. D. W. Roper, (Chairman): The problem of transportation is one of the projects of our modern civilization, and has always been an interesting subject to all of us who have to come down to our work daily and return at night; not only to us but to the other members of our family who have occasion to do shopping or visiting.

Some of us can recall that twenty-five years ago the highest development of transportation was the bob-tail car pulled by one horse or a mule, and one man served both as driver and conductor. After reading some of the complaints lately, as printed in the papers about not getting enough heat in the rush hours, (the company turning off the heaters to economize in electric power at the peak of the load) it occurred to me that back in the old days the people complained about not having enough hay in the bottom of the cars to keep their feet warm. So I suppose the service will always be a little behind the ideas of the traveling public.

In the early days, the car lines were rarely more than three or four miles long, and it required some thirty or forty minutes to complete the trip. A little later two-horse cars were introduced—somewhat larger and more comfortable—and the lines were lengthened some-

what. After that, cable roads were introduced, and they, with their increased speed, were able to carry the passengers a good deal farther in the thirty or forty minutes ordinarily used by the other method.

It is interesting to note that in all the developments that have occurred from the beginning up to the present time, the length of trip that the average commuter or passenger on the electric surface lines is willing to take, has not greatly changed, and beyond the thirty or forty minute trip there was then the same sudden falling off in the traffic as there is now; not that there is no traffic beyond the thirty or forty minute trip, but the traffic that goes beyond the length of that trip is small compared to the traffic inside of that distance.

In those early days, too, the cities had a sharper line of division, or wider gap, between the territory reached by the horse car lines and the territory served by the steam roads.

As the electric lines were introduced, they at first performed the same service as had been rendered by the two-horse car lines and cable roads; but from that time up to the present, they have gradually increased the amount of power in the motors installed in the cars, and this, with the improvements in the road bed, has permitted a corresponding increase in the speed, so that there has been a considerable increase in area served by the surface lines. Some years ago, when these electric cars first began to make a respectable speed, there was quite a falling off in traffic on some of the steam roads, where the two competed in one territory. As a result, some of the steam roads have taken off a portion of the trains which served the stations nearer the city, and have changed their schedules so as to have "express" service to the more distant points, which is the same as saying that they have increased the length of the ride which they can give a passenger during the thirty or forty minutes he is willing to spend in taking the ride.

In this city we have elevated railroads which, with their express service, can secure a fair share of the traffic in districts where they compete with the steam railroads. The recent improvements in the surface lines have brought about a redistribution of the traffic in many districts. People who formerly rode in the elevated railroad now find they can make better time in getting to and from their places of business on the surface lines. The elevated roads have in turn improved their express service and extended their lines so that they are drawing traffic from the steam railroads. Whatever may be the immediate cause of electrification of the railway terminals, which would include the suburban traffic, it can be considered as one step in the competition with the surface and elevated lines.

The average speed which can be attained by electric cars has been shown to be somewhat greater than that obtained by the steam roads, so that this electrification will make a good result in a further extension of the radius which can be served by the steam roads. Unless human nature changes more in the next twenty-five years than it

has in the past twenty-five years, we shall, after a while get to a limit of urban or suburban territory unless we can continue to increase the speed of our cars. Whatever the form may be, whether of steam roads, electrified steam roads or surface lines, there is always going to be a sudden falling off in traffic beyond the thirty or forty minutes ride. That means there will be a sudden falling off in the density of population at a radius of twenty-five or thirty miles.

Mr. W. B. Story, Jr., M.W.S.E.: I do not know that I have much to say that will add to the information given us by the speaker at the last meeting of the Society. His paper was extremely thorough, and historical in its nature; but as he drew practically no conclusions, there is not much to speak on, so far as his conclusions are concerned. There was, however, a conclusion drawn by one of the speakers following the presentation of Mr. Evans' paper, which is worthy of attention and possibly merits a few words of remark in regard to the ground for his conclusion. I would like to read that conclusion if the members will permit: "I think no one who has looked into the New York Central R. R. electrification, where the conditions are similar to those here in Chicago (in fact the Illinois Central R. R. conditions are probably more favorable for electrification than the New York Central), can doubt that the time has come when the Illinois Central R. R. should electrify." I am unable to agree with the gentleman referred to on this point, and while I have given the subject no scientific study from the point of view of the Illinois Central R. R., or the other roads who may possibly be studying that question, I hold that from the facts as given in the paper or brought forth that evening, there is nothing to show that this conclusion is merited. He did not base his conclusion entirely on the remarks of the speaker of the evening however. We have not had opportunity to study the electrification of the New York Central R. R. except in so far as has been presented by a speaker at an electrical meeting held in this city during the past year, and also from a paper which was presented before the American Society of Civil Engineers by Mr. Wilgus, formerly in charge of the electrification of the New York Central lines. The remarks of the speaker of the last meeting of the Society although historical in their nature, tended toward the above quoted conclusion, and after listening to the paper and the remarks made by him, one is led to the belief that the paper was prepared with the idea of saying that the electrification of the terminals is justified at the present time. I believe I am a broad enough engineer to think that whatever would serve transportation to best advantage should be adopted, but the point I wish to make is that so far no facts have been presented which show that electrical installation is justified on the terminals in Chicago at the present time.

There has, as you all know, been a great deal of talk about smoke in Chicago. So far as Chicago itself is concerned, that is the principal things in which it is interested at the present time. There are certain items of comfort in travel to be considered, but, as our Chair-

man has said this evening, in twenty-five years, or ten years, or five years of electrification, you will probably find a certain proportion of the people who will find something that is not quite up to what it should be. When you come to the smoke nuisance or dust on the present suburban railroads, I believe I am justified in saying it is due to the *general* smoke situation in this city, and that the greatest factor is not the Illinois Central, the North Western, nor any other of the railroads or series of railroads leading into Chicago, but that it is caused by the consumption of soft coal by the entire city. If anyone will walk down Michigan Avenue, when the wind is blowing toward the lake, and notice the smoky streets, I think he will agree with me that the smoke is coming from the city itself and not from the Illinois Central R. R. as we are led to believe by some of the papers.

In order to touch on some of the points brought forward by the speaker of the last meeting, I would like to review some of the reasons which the Author advances as justifying the electrifying of terminals, which are as follows:

“Electrification provides a system of working which gives efficient control, quick acceleration, allows us to get past disturbing points with a minimum of delay, does away with a lot of dead time for equipment, makes less switching, gives a higher speed and a lessened time of passage over busy tracks, allows of almost any train load being handled without much loss in speed, and, in general, allows us to work a terminal at about double the capacity it possesses under steam operation.”

In detail he has touched on practically all of these points, and in no place has he given any figures whatever as to the saving to be accomplished. The last line is the nearest to a definite conclusion which he draws. I claim that no one, as yet, can say that. It is possible that in papers that have been given on electrification of terminals this information may have been given,—how double the capacity may be obtained—but I wish to say the electrification of the New York Central lines should not be taken as an example for Chicago. The estimate on that work was over \$30,000,000 and the work is not yet completed; what will be the final cost, no one knows.

Let us take, for illustration, the Illinois Central R. R. There are no crowding conditions that require enlarged capacity and justifying the expense of electrifying. Electrification is only one of the elements in the total scheme which goes toward the increased facilities of the terminals, and therefore I do not think we can take that as concluding the question at all.

A number of the reasons which he has given in this resumé are enlarged upon; for instance, where he says that “certain noises incident to steam operation are objectionable, such as the puffing of the exhaust, the clank of the running gear and such pounding of the track as may come through the use of a reciprocating instead of a rotating motor.” He speaks of these noises. So far as the ordinary person

living in the suburbs is concerned, I believe these are small matters.

The author says, "the saving which may come from electrical working may be looked for at a number of points: In the first place the absence of dust, dirt and smoke leads to longer lived furnishings and less wear and tear on the rolling stock, and also to a lessened cleaning expense." As a matter of fact these things are very small and if the cars and motors are not kept clean you will hear a protest from the people.

Another reason given is, "the absence of smoke should result in longer lived steel work in bridges, viaducts and other metallic structures adjacent to the track." Then he spoils his own argument by stating, "Above a wooden flooring in "the bridge-work, where the metal work was shielded from the action of the gases, only a negligible amount of corrosion had taken place." I claim that this remark shows there is not much injury due to the coal smoke from locomotives. In the case cited it was probably a bridge over a track in which the steel work was down close to the locomotives, and doubtless the city had not taken proper precaution to protect the steel work. No bridge work will stand that; even though there had been electrical installation in that case, I doubt not that there would have been some depreciation of the steel work.

The author states that "a greater annual mileage capacity is available from the equipment by electrical working than by steam working." We are willing to admit that, but this is a question which does not concern the city. It is one of the elements that concerns a real saving, but there are no figures to show what that saving will be. It does not as yet justify the installation of an electrical terminal. Then details are given as to how these savings can be effected. We admit that there will be a saving in certain directions, but the amount and just what can be done were not given, and these are the things we would like to have somebody give us. I think you will find that the railways terminating in Chicago will be perfectly willing to start in and do the work, if it is proven that it is the best thing to do. The point at issue now is, it cannot be shown that electrification is justified.

A case is mentioned in the paper of an installation made in California because electricity was cheaper than steam. I happen to know about that particular case, and as a matter of fact the purpose of the installation was to sell electricity; the *cheapness* of the service had nothing to do with it. The corporation bought the railroad in order to use up some of its surplus electrical current; the deal was a mistake financially and therefore from an engineering standpoint. That was not proper power to put in at that time on that particular road. The author states that there are also large savings to be expected from electrical working from lessened repair bills, and then figures are given to show what this will amount to. In the first place no one knows what the repair bill will be. The electrical installations are not old enough and the types of locomotives are not determined definitely enough, to enable us to give correct figures, and no one can

say today what the repair bill is going to be. After the electrical installation has been in service ten or fifteen years figures more nearly correct can be obtained. Referring to the clause on a later page, "Repairs would also be cheapened because of a greater standardization of electrical parts," the idea is so new that there is not yet a standard; if there is, the electrical people have done more mechanically than most people I know. If they are able to say on the start that these parts are standard and are going to last fifteen or twenty years, they do well, but I have grave doubts that they can consider these parts as standard.

One gentleman stated in the discussion of the paper that the New York Central, after a year and a half of service, had ordered twelve more locomotives identical with the original locomotives, with the exception of a slight modification in the trucks. That was because the locomotives had not been in service long enough to determine wearing qualities. The author states that we may predict a maintenance charge of about 3 cents a mile for electrical locomotives against 8 to 11 cents for steam locomotives. I contend that on account of the absolute lack of knowledge, no one is justified in making such a prediction.

The statement is made that a saving is effected on account of there being less dead weight to be taken from place to place. Possibly there will be some saving in this, but it will be hard to measure. The only saving will be in the locomotive itself. It seems to be established that a steam locomotive will exercise less draw bar pull than an electric locomotive, and it is possible there may be some saving, but it is difficult to say what it will amount to.

In the paper there is some uncertainty as to exactly what is being spoken of. The proposition is treated in two ways: In one place the electric operation is spoken of as being easily handled on account of multiple units, and in other parts of the paper the locomotive is mentioned. The thing should be separated so one will know what he is going to use. In electrical terminals all the through trains will have to be handled by electric locomotives and you can have no multiple units, and the multiple unit arguments do not pertain to locomotives. The subject should be differentiated. We will admit that for a service purely suburban, with nothing but local trains coming and going within a radius of twenty-five miles, if you are building the railroad in the first place, the electric railroad is the proper one, but simply looking at the matter from that standpoint one is not justified in saying that the present terminals should be electrified. It is not proven by the figures given.

A further argument given is the facility with which freight can be handled at electrified terminals, but the author does not state that that same method of handling freight is available now. That method of storing freight is being used today in connection with steam terminals.

Again, on a later page, the author states that "an electrified terminal also presents the opportunity (because of cheap handling of

varied train weights and ready starting and stopping) of affording a local freight service analogous to the suburban passenger service. It is a problem with large retail merchants how to handle their out-lying deliveries. On an electrified terminal light freight trains with a car for each suburban station could be made up a couple of times a day and run out over the line, dropping a car at each stop, and picking up the cars on the return trip." This sounds very nice, but as a matter of fact it is entirely impractical so far as the ordinary way in which the ordinary freight terminal is handled. If you could handle it underground, from the basement of the wholesale dealer or store to the rails which would take it out to where it is going, it would be very nice, but freight is not handled in that way. When it comes to a railroad terminal, it seems as though all the freight that is going out of town wants to get to the terminal by 4 o'clock in the afternoon, and it is necessary to get the freight away from the doors as fast as it arrives, for the teams block the streets. If the steam railroads could find any way to deliver the freight a carload or two at a time, they would be glad to do it.

Now we come to the point where electrification is justified. There seems to be no question but that it is justified in the New York Central installation—not only the New York Central but the Pennsylvania R. R. In the case of the New York Central the traffic had reached such a condition that the tunnel through which the trains formerly passed became so congested it was practically impossible to handle the business; as some additional means of getting into the city had to be provided, electricity was one of the means by which it could be accomplished. Entrance to the Pennsylvania depot would be absolutely impossible without electricity. Several other cases are cited by the author, such as the Baltimore station. All of those installations are justified, and electricity is one of the means of the present day by which we can overcome things that could not have been attempted fifteen or twenty years ago, and where we come across any of those cases there is no question but what an electrical installation of terminals is justified. But those situations do not apply to Chicago, or any city situated as Chicago is, at the present time, although such an installation may be justified at some future time. Here in Chicago we have a plain spreading out twenty-five miles in every direction, and it is going to be a long time before electrical installation is justified, but when economic conditions require further steps to relieve the crowded condition, and the electricians can give us figures that will show where we can save money on electrical installation in the terminals, we will gladly take up the matter.

In looking over the history of electrical installation, which the speaker of the evening gives, which includes practically all the installations that are either now in use or which are contemplated the world around, it seems to be shown that the only places where these installations have been put in are where there are tunnel conditions or where the financial conditions will warrant. In the case of the

installations in Italy and Australia, as these were put in experimentally we know nothing as yet about how the experiments turned out and most of the work was done by the Government.

In regard to the Illinois Central R. R., the statement has been made that the work of electrification could probably be done for \$4,000,000. As a matter of fact that \$4,000,000 would doubtless have to be doubled, and that would not include the power factor. The moment you have to earn the additional interest on that money you have to show, not only a large saving but a large increase in business in order to justify it.

Referring to the question of the figures given relative to maintenance, I find in the discussion of the paper the following: "The annual charges against these two styles of locomotives, as given by Mr. Wilgus, including interest, depreciation, repairs, etc., were, as I remember the figures,—for a steam locomotive, \$4,500, or 30 per cent. of the first cost of the locomotive; for an electric locomotive, \$3,700, or 12½ per cent. of the first cost of the locomotive," and from that the speaker proceeds to build up the fact that the maintenance of the electrical equipment, while costing (as shown previous to this statement) \$1,200,000 as against \$750,000 for the steam locomotives, would more than justify the difference. (I should have mentioned this when speaking about the relative cost of operation.) I claim that the science of the electric locomotive and of electric locomotive operation is not old enough to justify saying that the maintenance cost is going to be \$3,700 a year, and all you have to do is to increase that three or four hundred dollars to find the figures do not show any such saving and the whole thing changes; therefore, it does not prove that the Illinois Central R. R. should electrify at the present time.

At the last meeting the remarks seemed to be all from an electrical standpoint. I have therefore thought I would be justified in inflicting the electrical men with one side of the story.

Mr. W. E. Symons, M.W.S.E.: The paper is a very valuable one, and while I do not agree with the author in some respects, this does not necessarily detract from the value of the paper or the weight of the author's views.

Taking first the question of dust, mentioned in the first page, which seems to be charged to that arch-criminal,—the steam locomotive. As a matter of fact, the dust in railway trains is caused by air currents due to the train's movement, and is not in any way due to the use of a steam locomotive. Less than three per cent of the foreign matter in railway trains comes from the steam locomotive burning soft coal. Because of the fact that small particles of unconsumed carbon fall on one's clothing, face or hands, making black spots, if perspiring, most passengers imagine that it is the engine that creates all the dust and dirt. With an electric locomotive, or a steam locomotive burning oil or anthracite coal, if the road-bed and other condi-

tions are equally favorable to dust, the train will be just as dusty as if bituminous coal were used, though not quite so black

Later on, the author mentions that "the maintenance of such nuisances, in addition to being disagreeable to the public, is injurious to public health and tends to depress property values along the line of route both because of the positive damage done from dirt and gases and from the unattractive means of transportation offered." Taking first the question of property values, and applying the case of the Illinois Central R. R. (which seems to be held prominently before the Chicago public at present); we may go back to the time when the Illinois Central R. R. was built; at which time I presume that the land where the terminal is now located was worth perhaps \$20.00 per acre, possibly less, while the land further out of the city through which the road passed was worth probably \$10.00 to \$5.00, and on the outskirts may be less. There is no corporation, individual, firm or industry that has done more in the way of enhancing the value of the property along its line, than the Illinois Central R. R., and today some of that land is worth \$20,000 to \$30,000 per acre. The railroad company built its line mostly in open country; people then came and built homes alongside the railroad, many of them making fortunes thereby. Now these same people complain about the dirt and noise caused by the railroad which made the place habitable. This I contend is hardly logical or consistent in the face of all the facts.

The second indictment is that steam transportation is an "*unattractive means of transportation*;" I can hardly reconcile this statement with what we Americans are so proud to designate as our beautiful and palatial trains handled by the most superb specimens of steam power, that throb with life, and, when in action, are the very picture of life. A fine steam locomotive in action is, to my mind, as beautiful a piece of work, from an engineering or artistic viewpoint, as human genius can produce, and I can hardly agree that the passenger trains running out of Chicago are unattractive because of the steam locomotive.

Again, there is this statement (thoroughly analyzed by the previous speaker); "The saving which may come from electrical working may be looked for at a number of points; in the first place the absence of dust, dirt and smoke leads to longer lived furnishings and less wear and tear on the rolling stock, and also to a lessened cleaning expense." The cleaning expense depends almost entirely on climatic conditions and the country through which the equipment is used. The equipment will go much longer if hauled through a country well grassed over and with no sand, than if hauled in and out of such a city as Chicago where there is much sand and dust, and excessive smoke from chimneys. As to the wear and tear of rolling stock, this is largely a question of track conditions. Track that is in poor condition is hard on rolling stock. It is also due to some extent to the character or capacity of the motive power and the manner of handling

it, and if, as the author states further on, we are to have electric locomotives of largely increased efficiency (25 per cent I believe), then we may look for a larger percentage of our freight and passenger equipment being in the shops for repairs, than at present. As it is now, the claims for damage to contents of cars, have increased largely during recent years because of the violent handling of cars by heavy locomotives while "switching" in the yards. When it comes to a locomotive 25 per cent more powerful than heretofore, we may look for still greater destruction of cars and contents.

The author states that "a greater annual mileage capacity is available from equipment by electrical working than by steam working." This particular feature is governed largely, as mentioned by the previous speaker, by conditions imposed on the railroad by the people. Where a heavy local business prevails, the mileage made by freight or passenger cars is limited accordingly. The average run of freight cars is about 25 miles per day, while passenger cars make all the way from 60,000 to 100,000 miles per year, depending largely on the character of the business. Of the local trains running out of the city, very few make the mileage of trains that go to the Pacific Coast, or other long runs. Therefore, it makes no difference as to the kind of locomotive hauling the train. The mileage will bear a close relation to the character of business that the trains handle, and this is controlled entirely by the conditions.

In regard to the "lessened switching and added movement under electrical than steam working," I cannot understand why the switching movement is lessened. Railway companies do not do any unnecessary switching, and, regardless of the kind of locomotive used, whether it burns oil, coke, bituminous coal or is operated by electricity, the cars remain undisturbed unless it is absolutely necessary to switch them.

With respect to the standardization of steam locomotives, I must say that it has not reached the degree of refinement that it should, although wonderful progress has been made in some directions. I wish to call your attention to the following as lessons in standardization:

STANDARDIZATION OF LOCOMOTIVES

No. 1. In reviewing the locomotive equipment on a certain well known railway in the Middle West, it developed that the total equipment, consisting of * * * 300 locomotives, was so diversified in type, class, kind and size, as to be impracticable of standardization to any considerable extent, except in the old obsolete locomotives. Of the Compounds there were three (3) kinds, namely,

Cross, Tandem and Vaucrain

and these in turn were composed of four (4) different types, viz:

Consolidation, Prairie, Ten-Wheel and Mogul

These twelve (12) combined classes and types of compound engines were still farther differentiated by the wide range of size in

cylinders and consequently of the working parts in connection therewith.

A glance at the following table No. 1, showing the number, type, kind, size of cylinder and ages of these compound locomotives proves the impossibility of standardization, even in a modern locomotive, which, from an engineering standpoint, is more economical in the use of steam than the single expansion engine, but which may be far more expensive in net results when the principle is applied in such manner as to defeat other paramount factors in the economy of locomotive operation.

TABLE No. I

No.	TYPE	KIND	SIZE OF CYLINDERS	AGE
1	Mogul	X Compound	21 x 35 x 28	17
2	Mogul	X Compound	21 x 32 x 24	17
4	10 Wheel	Vauclain	15 1/2 x 26 x 28	9
10	10 Wheel	X Compound	22 x 30 x 28	8
26	Prairie	X Compound	22 x 35 x 28	6
20	Prairie	Tandem	16 x 28 x 28	6
10	Consol	Tandem	22 x 35 x 32	6
73	4 Types	3 Kinds	5 different Sizes	6

From the foregoing it may be safely assumed that whatever economies may be reasonably effected from the application of the compound principle, over that of the simple, the same is not within the range of possibilities on the particular line in question, for several reasons, namely; increased first cost, diversified types and kinds and not only the impossibility of standardization among these particular engines, but the fact that standardization with any particular series of these engines and the remaining 227 engines is an impossibility. While it is possible and probably true that in such parts as Driving boxes, Shoes, Wedges, Grate Bars and Tenders complete, interchangeability as between compound and some of the simple engines may be possible, such parts, however, as Valves, Valve Stems and Yokes, Pistons, Piston Rods, Steam Chests and Covers, Cylinder heads, Main and side rods, Crank pins, Rocker arms, Brasses and many other parts which should be common standard to all modern engines will not interchange and the small percentage of engines that will admit standardization renders it practically impossible to establish any standard at all. This condition on a road of some considerable size may be generally similar to the author's observations. This, however, is not the rule, and does not represent accepted practice on well managed railways, as will be shown by the directly opposite conditions reviewed in the next following example.

DETAILS OF STANDARDIZATION

No. 2. As an illustration of what may be done in the way of standardization of equipment, reference is here made to the Harri-

man Lines, on which the work of evolving common standards from the various kinds, types and sizes of both locomotives and cars have resulted in minimizing the number, variety and quantity of material on hand to the lowest possible number, or quantity. The units or classes being designated as "Common Standards of the Associated Lines."

Prior to taking up this work the various lines, which are embodied in, or form a part of, the present system of about eighteen-thousand (18,000) miles of railway, had been under separate management, and in the design and construction of both motive power and equipment, there was not only a wide range of difference in size, type and general design of engines and cars intended for like service, in a generally similar country, but these were also still further diversified by the individual ideas of different officers in charge of the motive power departments at different times. The combination resulting in a mixture of both motive power and equipment, from which it was impossible to select any one type, design or class that was suitable or acceptable to the other lines. It therefore followed, that the work of standardization was of no small proportions. This was commenced in 1902, and during the next four (4) years the heavy types of locomotives for both switching, freight and passenger service were reduced to five (5) different classes, as follows:

1. Light switching.
2. Heavy switching.
3. Consolidation.
4. Atlantic and
5. Pacific.

There was no necessity for providing any light power, as there was an ample quantity on hand.

The following table gives the dimensions of the engines in question, above mentioned:

Class	Cylinders	Driv- ing Whls.	Steam Pres- sure	Grate Area	Heating Surface	Total Weight	Weight on Driving Wheels
		Diam.	Lbs.	Sq. Ft.	Sq. Ft.	Lbs.	Lbs.
Light Switching	19 in. x 26 in.	51 in.	175	30.2	1563.0	140,000	.....
Heavy "	20 in. x 26 in.	57 in.	180	30.2	1822.4	160,000	.....
Consolidation..	22 in. x 30 in.	57 in.	200	49.5	3397.3	208,000	187,000
Atlantic	20 in. x 28 in.	81 in.	200	49.5	2654.9	196,000	105,000
Pacific	22 in. x 28 in.	77 in.	200	49.5	3048.0	222,000	141,000

In working out the design of these engines, many of the parts are interchangeable throughout over the entire system of 18,000 miles of railway; in fact an engine, or a number of engines, might be transferred from the Omaha division of the Union Pacific R. R. to the Los Angeles division of the Southern Pacific R. R., without the necessity of sending a dollar's worth of material from the point

where the engines were sent; neither would it be necessary for the motive power, or store departments at Los Angeles to add any additional stock or extra parts in order to be able to take care of these engines on their arrival, as the parts which either wear out, or fail in service, are of the same size or dimensions all over the entire system.

The interchangeability of parts includes:

Driving boxes.	Connecting rods.
Driving brasses.	Cylinders.
Shoes.	Frames.
Wedges.	Driving axles.
Driving Wheels.	Engine trucks.
Eccentrics and straps.	Wheels and axles.
Crank pins.	Engine truck frames.
Valve motion details.	Bumpers and pilots.
Valves and	Tenders, their trucks and acces-
Pistons.	sories.
Cross heads and	Cabs.
Guides.	Boilers and their accessories.
Guide yokes and other connec-	Cylinders.
tions.	Guide bars, etc., etc.

Of course, it is not possible to make each identical part of a size or dimension so that it can be used on any other engine; such articles, however, as pistons, with the packing rings that are used in connection therewith, can be, and should be of a uniform standard for all engines with the same size cylinders. Piston rods should also be interchangeable with all engines of the same stroke and cylinder size; driving wheel centers of the same diameter can be made interchangeable, even though the spread of cylinders may be different, by providing an off-set in the hub of the driving wheel centers so as to allow for the difference in cylinder spread; different patterns for wheel centres are therefore unnecessary and the expense of carrying extra wheel centers in stock is entirely avoided.

On the above mentioned lines, which embrace, about eighteen-thousand (18,000) miles of road, with about two-thousand-four-hundred (2,400) locomotives, five (5) different kinds or types are all that is necessary for the different kinds of service, which includes everything from the level valley division to the heaviest mountain service in America, and as this includes two (2) different types of heavy passenger engines, it is fair to assume that one such type, or a total of four (4) different types of engine would be ample for the line in question, or any of the trunk lines, where proper effort is made in the right direction towards standardization.

This I think shows quite clearly thorough standardization is not only possible, but as a matter of fact that the question has been completely solved, and thoroughly demonstrated.

Still later in the paper the question of repairs is mentioned, and this

was also referred to by the previous speaker. I have some data to offer in that connection: 3 cents per mile for electrical locomotives, as against 8 to 11 cents per mile for steam locomotives, are, I believe, the author's figures.

I have before me the figures on the item of repairs of three prominent railway companies running out of Chicago; (two of them are of the largest trunk lines) the costs for repairs last year were as follows: I will designate them as A, B and C, A 4.42c, B 3.53 c, C 5.64c, or an average of 4.53c per mile. These companies own and operate the heaviest locomotives running out of this city. Going a little further into the matter of expense, I have actual figures covering tests between electric and steam locomotives, and I shall quote from a statement made by Mr. J. E. Muhlfeld, General Superintendent of Motive Power and Machinery, Baltimore & Ohio Railroad, who has had both steam and electric locomotives in his charge for several years. About a year and a half ago a paper was read before the New York Central Railroad Club by a well informed engineer, upon the use of electric *versus* steam locomotives, and in the analysis of that paper Mr. Muhlfeld submitted a written discussion from which I quote:

"Where considerable expenditures are involved, it is the general rule in electrical and mechanical work, to prepare estimates showing the cost for the construction of the proposed equipment, and to specify the saving and benefits to be derived from the inauguration of its use, previous to the authority for the work being given. From several years experience it has been found that the anticipated operating results from new construction do not always materialize, and it will be interesting to learn whether this may not be the outcome, in event some of the estimated figures that have been given to use, indicating the improved efficiency and economy to be derived by the substitution of electric for steam locomotives, are taken as the basis for making such an investment.

"From present performances, electricity, as applied to locomotives for the handling of traffic on steam lines, implies luxury, and it will, no doubt, have to be put through the same process of liquidation that labor and material must undergo, before results comparable with past and present steam locomotive performance will be obtainable.

"Electricity undoubtedly has its place on railroads for use as power and lighting at shops, stations and terminals; for signaling and similar operations; for city, suburban and inter-urban motor car operation, and for tunnel and underground locomotive service where the use of steam locomotives may be impracticable, but for the handling of passengers or tonnage, at terminals, or for any considerable distance, the electric locomotive, with the present state of the art, when compared with the steam locomotive, is an expensive proposition.

"The following comparison of shop charges for locomotive "classified and running repairs, made during recent periods "covering from one and one-half to two and one-half years' "performance, may be of interest.

"Three passenger electric locomotives, each consisting of two "sections, with two pairs of independent driver-wheels per sec- "tion, total weight of locomotive 320,000 pounds, tractive power "28,000 pounds, cost for mechanical and electrical repairs per "hundred miles actually run, approximately \$19.20.

"Two freight electric locomotives, each consisting of two "sections, with four pairs of independent driver-wheels per sec- "tion, total weight of locomotive 320,000 pounds, tractive power "70,000 pounds, cost for mechanical and electrical repairs per "hundred miles actually run, approximately \$12.70.

"One Mallet articulated type of compound steam locomotive, "composed of two sections, each having three pairs of coupled "driver-wheels, total weight of locomotive 350,000 pounds, trac- "tive power in compound gear 74,000 pounds, cost for mechan- "ical repairs per hundred miles actually run, approximately "\$5.75.

"Thirty-five passenger steam locomotives, Pacific type, total "weight of locomotive, excluding tender, 230,000 pounds, trac- "tive power 35,000 pounds, cost for mechanical repairs per hun- "dred miles actually run, approximately \$4.35.

"One hundred and seventy-five freight steam locomotives, "Consolidation type, total weight of locomotive, excluding "tender, 290,000 pounds, tractive power 42,000 pounds, cost for "mechanical repairs per hundred miles actually run, approx- "imately \$3.15.

"The above would make the average cost for all repairs to "these locomotives, per 1,000 pounds of rated tractive power "at ten miles per hour, about as follows:

	Per 100 Miles Run
"Passenger electric locomotive.....	68 cents
"Freight electric locomotive.....	18 cents
"Passenger, steam, 'Pacific'.....	12½ cents
"Freight, steam, 'Mallet Compound'.....	8 cents
"Freight, steam, Consolidation.....	7½ cents

"Furthermore, by comparing the entire working expense of "locomotives of similar tractive power, which have been operated "in similar service, during a two and one-half years' period, we "have the cost per 100 miles actually run of approximately "\$84.00 for the electric, and of approximately \$41.00 for the "steam locomotives. These figures are comparative for electric "and steam locomotives of corresponding ages, but do not take "into consideration the interest, depreciation, taxes or insurance,

“nor do they include the expense incident to the maintenance of such equipment as feeders, third-rail, bonding wires, insulation, safely cut-out switches and auxiliaries, which are required only in connection with electric locomotive operation.

“The original cost for the comparative locomotives may be made on the basis of the total working weight, excluding the tenders of steam locomotives, and the cost for each when new built, would be about as follows:

	Per Pound
“Passenger electric locomotives.....	20 cents
“Freight electric locomotives.....	12 cents
“Freight, steam, Mallet locomotives.....	9 cents
“Passenger, steam, Pacific locomotives.....	8 cents
“Freight, steam, Consolidation locomotives.....	8 cents”

The author refers to the fact that some lessening in the track maintenance may be expected, although he does not make any strong claim. It occurs to me that it might not be out of place to mention a fact sometimes overlooked, that the total expense of track maintenance is not entirely governed by the kind of locomotives, but that perhaps 80 per cent. is due to deterioration, through the action of the elements, and about 20 per cent. to its wear in service. The reduction in cost of track maintenance by the use of electricity in place of steam, would be rather questionable if the number of trains were not materially reduced, and, as I take it, they contemplate increasing the number of units, which would shorten the life of permanent structures rather than increase them.

The question of freight terminals has been thoroughly reviewed by the previous speaker, but I will add just one thought. There is no corporation or person who can evolve a plan of operating freight terminals and put it into effect unless it reasonably serves the patrons of the road. What is put into effect, is what the patrons require and demand, not what the railroad officials might want themselves. We are catering every day more and more to the wishes of the people. This is proper and correct in many ways, particularly so in the matter of supplying such transportation as the patrons of the road desire, want and pay for. Some years ago, when our roads were handling principally through-traffic, the question of utilizing terminals and freight houses to better advantage was susceptible of solution on some such plan as the author has in view, but today it would not be within the range of possibilities.

In years gone by the merchants came to the city about twice each year to buy goods, but today they come every few weeks, and sometimes oftener, while others use the long distance telephone, order what they want, and add “I want these goods on my counter tomorrow morning.” This means that, regardless of the size of the shipment, it must go out that night, and where there are thousands of such orders every day in all the large jobbing centers, it is plain that

any plan contemplating the maximum utility of a freight terminal house or tracks, that in any manner interfered with the prompt handling of this class of patronage, would prove ruinous to any railroad company, and the kind of power used for handling the cars is entirely foreign to the question.

With reference to the electrification of lines in the vicinity of San Francisco (which has been so ably reviewed by the previous speaker), I might add some data.

The Oakland electric line referred to, is commonly called the *Key Route*, and is a well equipped road.

The Southern Pacific Co. is considering the electrification of a considerable portion of its lines in the vicinity of San Francisco.

The situation there at present is about as follows: Oakland pier is the terminal for west bound, or trans-continental trains, and also a heavy suburban service. Alameda pier, which is nearby, is also a terminal for a heavy interurban travel, while the electric line above mentioned does quite a considerable passenger business, taking its passengers across the Bay from a nearby pier on ferry boats, the same as the Southern Pacific Co. The Southern Pacific Co. has a normal ferry service every twenty minutes from Oakland pier direct, and also from Alameda pier. They run from each of these piers regularly three suburban trains, with one swing train, making seven in all. There are fifty-six regular west-bound passenger trains bound for San Francisco which have their terminals at these piers.

During "fleet week" last May, a very severe test was given these terminal transportation facilities and the results from this test are germane to this subject, in that they pass judgment on some of the claims made for electric transportation over steam. During the fifteen days of what was commonly called "fleet week" the Southern Pacific Co. delivered 1,899,836 passengers into San Francisco, 1,541,616, being through passengers, and 358,220 local passengers. This was at the average rate of 128,255 passengers per day, or 6,932 per hour for the entire fifteen day period, 18½ hours per day.

On May 6th, the day the "fleet" came into the Bay, the Southern Pacific Co. handled 558 trains, or a train every two (2) minutes, and 178,755 passengers; the passengers being handled at the average rate of 10,000 per hour, and during the heaviest movement about 18,000 to 20,000 per hour, making an average of about 10,000 per hour for the movement period of 18½ hours.

Not a delay, hitch, or accident occurred, although much of this business was handled by steam locomotives built at the Sacramento shops of the Southern Pacific Co. thirty years ago, and commonly considered obsolete.

The *Key Route* Electric Line made a notorious failure of handling large crowds of people on their line. Early in the day they had several thousand passengers blockaded on their line, most of them on their pier, and it was almost impossible to get them off in either direction. It was only through the counsel of cool level heads that

a riot with probable loss of life was avoided. This tends to show that an electric road, with all the modern electric equipment, does not always solve a transportation problem after all; it not infrequently comes down to an operating question pure and simple rather than the kind of motive power or equipment.

In the case of the Illinois Central R. R., which seems to be under indictment by the public for causing smoke, it occurred to me a long time ago that there were stronger grounds for filing complaint against the owners of buildings, than against the Illinois Central R. R. As the previous speaker said, the wind is frequently in the west, and then most of the Illinois Central smoke is blown toward the lake, and nothing is said about the big roads that run down through the center of the city, and always add their quota of smoke, regardless of wind or weather. So it occurs to me that either from the standpoint of an engineering proposition or of civic pride, the lines have been rather narrowly drawn in the author's paper; and that in dealing with this question the citizens of Chicago are not as consistent as they should be. No citizens are more anxious to have the very best means of transportation than the Illinois Central officials, yet as a matter of fact, I am inclined to believe, that the people interested are not approaching the matter in that spirit of co-operation essential to a successful solution.

The matter of cost has also been very ably handled by the previous speaker, and I have not made any estimate on the cost of electrifying the Illinois Central terminals, but inasmuch as the author of the paper does not give details, I may possibly be pardoned for referring to this item in similar terms. My views are that if *twice* \$4,000,000 were furnished at the commencement of the work, that before the work approached completion the men in charge would come back for another four million. I do not believe it can be done for twice four million dollars, neither do I think electrification in the present state of the art should be forced upon the Illinois Central R. R. alone at any price. There are many other well known methods of abating the smoke nuisance within easy reach of the authorities that should first be invoked against the real offenders.

*With respect to my exact position in this matter, it appears to not be clearly understood by all, possibly I may not have made it sufficiently clear, and in explanation will say, that while I appreciate the complimentary reference to my defence of the steam locomotive, yet I feel that it needs no defence, as its reputation will stand alone against all comers without fear of injury or loss of prestige, retiring with credit from such special transportation fields as it may have been instrumental in building up, to a condition that will justify the use of such other kind of motive power as has, by thorough practical test, been found by the railway officers in charge of the properties to have demonstrated its fitness to supersede the steam locomotive, without

*Additional matter, submitted later by letter.

in any way jeopardizing the interests of the companies' patrons or impairing the capital account.

It is from the above standpoint, that I have attempted to weigh, in an unbiased manner, the respective claims and merits of steam versus electricity as a means of motive power for large railway terminals.

Railway Companies are technically manufacturers in a double sense, as they both manufacture and sell transportation, and in a more or less degree must operate a manufacturing plant to maintain or build new equipment.

During my active railway service it has been incumbent upon me to solve many problems, involving the design, construction, purchase and operation of the most suitable means of producing transportation for both freight and passengers, and under a variety of conditions; I therefore cannot consistently accept the single (and to my mind somewhat restricted) position of advocating a certain kind of motive power, without a pretty general knowledge of *all*, and although it may at first sound strange to some, yet I do not hesitate to say that the proposed use of electricity as a motive power for large passenger terminals has no stronger advocate, or warmer friend, than myself. In fact, it is my belief that the principal terminals in most all our large cities will be operated by electricity in the not far distant future, and in line with this thought sometime ago I prepared a tentative plan for an electric zone extending twenty-four miles from the center of the city of Chicago.

I do not believe, however, that any system or plan has yet been sufficiently worked out of the *experimental field* that railway managements (who have the ablest electrical and engineering talent in the world at their disposal) would be justified in adopting as a standard, in lieu of steam power of known reliability, on so large a proposition as the Illinois Central terminals, and it is *my advocacy* of electricity, as an *ultimate* means of suburban transportation that prompts me to take the position I have in this matter at this particular time, believing as I do that any definite steps taken by the citizens of Chicago, looking to the abatement of the smoke nuisance in our city, should be directed toward all offenders, in proportion to their guilt, and the known available remedies within their reach, rather than adding to an already over-wrought public sentiment which seems to be particularly unfriendly towards a certain corporation, while remaining passive or painfully silent with respect to the responsibility of others, many of whom are equally or more guilty.

Some figures have been prepared on this subject showing the division of responsibility for the smoke nuisance in the city, to be divided about as follows:

Steam locomotives	13%
Stationary plants	87%
Total	100%

A high degree of accuracy was not possible in working up these figures, as the necessary information was not in all cases to be secured; failure to furnish which was, however, about equally divided, and it is thought they represent a fair average, or happy medium between *high* and *low*, and as there are some twenty-six railway lines terminating in the city, it would seem to me to be more in keeping with the real facts to charge the Illinois Central R. R. Co. with causing about one-fifth ($1/5$) (based on proportion of engines in the city limits) of 13% of the smoke nuisance, except when the wind is from the west, during which period they should be *partially* if not *wholly excused*.

In the matter of cost which has already been referred to, I wish to make further reference to what appears to be a very low estimate, namely, \$4,000,000.00. The Illinois Central R. R. Co. have in the city limits each day approximately 196 locomotives, and if these were displaced by an equal number of electric locomotives at \$30,000.00 each, the cost would be \$5,880,000.00, or \$1,880,000.00 more for the locomotives alone than the author estimates the entire change would cost.

It is more than likely that these electric locomotives could be secured for less than \$30,000.00 each; in case of a change, however, more electric locomotives would be required than are now in use of the steam engines, this to meet increased number of trains, and to have reserve units ready for extra use, to meet such emergencies as fluctuations of traffic, accidents, etc., require, which contingencies can now be met by drawing power from other districts of the lines, but which could not be done after changing to electricity; it may therefore be safely assumed that the value of the additional number would about equal, if not exceed, any reduction in cost per unit.

Mr. W. L. Abbott, M.W.S.E.: I think that these gentlemen who have grown gray in the steam railroad business are entitled to our sympathy. We can readily appreciate the commotions which disturb when some reform or a newer system lays sacrilegious hands on that thing of beauty—the steam locomotive. I have listened with considerable interest to the statements which have been made here and backed up by figures and good arguments that electric railroading is a thing unaccomplished and not feasible. One might be tempted to inquire in what “Sleepy Hollow” these gentlemen have slumbered during the past twenty years, which have witnessed the development of electric railroading. I venture to say that within one hundred miles of, and including Chicago, there is more electric railroading done now than there is steam railroading. The prohibitive expense which would be entailed in changing from steam to electrical equipment has been dwelt upon, but no reference has been made to the elevated railroads, which changed their entire equipment in a single night, as it were, and scrapped a complete equipment of steam locomotives.

The statement that steam railroad engineers would gladly adopt the new form of propulsion if it were considered to be economical, recalls

the story of Cornelius Vanderbilt, who laid the foundation of his great fortune in steam-boating on the Hudson River, and who looked with unconcern upon the building of steam railroads along the river banks. He felt perfectly confident that he could hold his business against any such new and untried means of transportation, and it was not until the railroad trains were in actual operation, making faster time than his steam-boats, and making serious inroads into his business, that he awoke to the fact that there was something after all in the possibilities of those wagons than ran on rails; so one afternoon he stepped into the office of the railroad company, purchased the outfit, and thereafter developed the art of railroading to a very high point of efficiency. The conservatism of railroad men at the present time is such that they have looked with equal unconcern upon the construction of electric roads paralleling their own lines, even when their own rails were worked to but a fraction of their capacity, and it is too early even now to say that they have awakened to the realization of what this electric railway construction will mean to them within a very short time.

I was surprised to note in the paper before us that sixteen different roads in this and other countries either contemplate electrification or are already electrifying their terminals, and when we consider that the suburban business of Chicago is equal to that of any city in the world, the conservatism of the steam roads centering here and their backwardness in adopting this new form of propulsion does not reflect credit upon Chicago in its pretense of being one of the most progressive cities in the country.

Mr. Wm. B. Jackson, M.W.S.E.: I care to add little to the discussion, but will say that certainly we all must highly appreciate having this matter presented from the standpoint of the steam railroad men, and I always feel that we who have such ardent belief in the great possibilities of electric power, and who believe we can perhaps see farther than some others, do well to hear the other side of the question. At the last meeting we had the question treated very fully from the electrical viewpoint, and now we have had it treated from the steam railroad point of view. I am wondering whether Mr. Camp, who has been publishing some very interesting articles on both the steam and electrical side of the question, may not be able to give us something of the middle ground, so we can all decide just where the question of steam transportation ends and electrical transportation begins.

Mr W. M. Camp: The electrification of railway terminals is indeed a very important subject, and I believe it is one which ought to be discussed more thoroughly than it has been. With the citizens of Chicago just now it is a very live subject on account of the agitation against smoke from railroad locomotives; so it is of intense local interest, in addition to being of very general interest to engineers and capitalists. Nevertheless, I think this agitation on the part of the non-technical public is driving the authorities, and to quite a large

extent the electrical engineers, to hasty conclusions as to what the possibilities are for electrifying steam railroads; and I am inclined to think that the author, also, is rather hasty in some of his conclusions and that some ground which he takes is rather far fetched. I therefore think it is advisable for the steam railroad companies to use a great deal of deliberation in deciding upon the electrification of their terminals. What a railroad management must consider is whether the additional investment for electrification is going to pay; whether there will be enough decrease of expense in operation or enough increased traffic, arising from whatever advantages there will be in electric operation, to pay for what it costs.

I agree with what the author says in the first paragraph of his paper about the need of electric transportation in tunnels, especially tunnels carrying a dense traffic at terminals. For tunnels of moderate length, out on main lines, there are installations of fanning machinery which are quite efficient for the purpose of clearing them of smoke; and where the passage of trains through tunnels so equipped is infrequent or at more or less irregular intervals, this ventilating machinery is giving fairly satisfactory service. For tunnels at terminals of cities, however, where trains are liable to follow one another at close intervals, it would seem that the blowing of sufficient currents of air through the bore to keep it clear of smoke is not practicable. I think, too, it may be taken as a settled thing that in such situations the steam railroads will be compelled to electrify their terminals, whether or not it is economical from an operating standpoint, and regardless of the cost, as was the case with the New York Central R. R. The principal consideration there, was that they were operating through a tunnel where steam trains were following at very close intervals, and the presence of the smoke and steam obscured the signals, which resulted in a bad wreck. That does not lead to the conclusion, however, that the electrification of all steam railroad terminals on the surface, in large cities, will be an economical and logical thing to do.

Now in regard to this smoke question. As one of the previous speakers has said, I think the steam locomotives in Chicago are making only a small part of the smoke. In sitting in my office on the thirteenth floor of the Manhattan Building, while a wind was blowing from the west, I have often had difficulty in seeing the tower of the Auditorium hotel, on account of smoke. That condition could not be laid to the Illinois Central R. R. Have you ever observed the dense clouds of smoke which come from the chimneys of the Illinois Steel Works? and have you heard any complaint about that? Do we hear of any steps being taken to eliminate the smoke at the Stock Yards? Now from either one of these sources one may see, almost any day, a cloud of smoke from one-half mile to one mile in width and several miles long, floating over some part of the city and turning about as the wind listeth. It is no uncommon thing, right here in the heart of the city, to see a larger column of smoke emerging from the chimney of one of the department stores or one of the large office

buildings than you will find coming from a roundhouse full of locomotives. So, as Mr. Symons has said, I believe the agitation against the Illinois Central R. R. is rather partial, considering that there are five or six other terminals right in the heart of the city. We have heard no agitation whatever about them. Of course, public clamor is stirred up because of some annoyance from smoke; and because the railroads are making a considerable amount of it, the manufacturing and other industrial or commercial plants that are making ten times as much, get off on small fines once or twice each year, and we hear no agitation calling for electrification of them. Why is it not just as reasonable to propose that all power-using establishments of the city install electric drive as that the railroads should do so? There is a very large class whose sense of proportion in regard to this so-called "smoke nuisance" is ridiculous in the extreme. For sentimental reasons it has become fashionable in these days to look to the railroads as the source of many of our troubles, and, with the average citizen, there is no time for investigation, or even for casual observation.

But let me remind you that every wide-spread complaint about some little discomfort to the dwellers in our great commercial and manufacturing centers is no good reason why engineers should take sides with undue haste on questions of public utility. The inhabitants of a large city, like Chicago, as a whole, have never lived contentedly and they never will. When they are not complaining about smoke it is something else. A large class would do away with our elevated railroads, because of the noise or because they are unsightly. The time of the year will soon be around when our newspapers will be publishing hysterical editorials about muzzling the dogs, and some people object to cats at all seasons. Others are greatly annoyed by the playing of children. In spite of our highly organized city government and correspondingly high rate of taxation, the streets are dirty and dusty, and frequently filthy. Largely out of humanitarian motives the steam railroads have gone to enormous expense and elevated their tracks above the streets, but the recklessly-driven automobile remains on the surface; and still we find no organized opposition to some of these real perils, or determined action to have the streets maintained in respectable condition. These things only go to show how miserable and inconsistent some, or all, of us can be over evils both imaginary and real; and it will always be thus. The man who expects to live entirely at peace and in comfort must either be a philosopher or else get out of the city. The whole point of the matter is whether the smoke from locomotives, by itself, is enough of an evil and public nuisance to justify enormous expenditures for electrification of the steam roads, unless thereby some compensating advantage can be found for the railroads. I think careful study along the lines above indicated will show that all the alleviation possible in this direction would be too small in comparison with existing conditions which the public seems to have no disposition to correct.

Now let us give attention to the idea, which seems to be entertained by some of the electrical engineers, to the effect that a change to electrical operation of any existing steam railroad is a very simple problem. The author of this paper says:

“Indeed it may be stated that electric locomotives for handling through trains and electric equipment for suburban cars are as thoroughly standardized today for a given type, as our steam locomotives.”

With this opinion I must beg leave to differ entirely, for I believe that electric locomotives for any requirements of steam road service—either suburban or through traffic—are, as yet, largely experimental. If the electrician thinks that he has solved the problem as soon as he has applied motors that are powerful enough for the contemplated locomotive unit and reliable in operation, I have only to tell him that the development of a satisfactory locomotive machine is, at that stage, only begun. Some one will refer, of course, to the example of electrical operation in the Baltimore & Ohio R. R. tunnel, in Baltimore, where heavy passenger and freight trains have been handled successfully since 1895, but the conditions there are special. These locomotives haul the trains up grade, at slow speed, in one direction, and coast back in the other direction. I do not think the conditions there can be compared with any that we have to deal with in Chicago. Everybody thinks he is posted as to what they have done in New York, but let it be understood, with respect to the electric locomotives of the New York Central and the New York, New Haven & Hartford railroads, that their operation has not been smooth sailing from the start, by any means.

Before a decision was reached as to what type would be used on the New York Central R. R. an experimental track was built at Schenectady. They constructed a locomotive on lines of the design which is in service there now, and began to run it. As soon as they began to get the locomotive up to speed they found it hard running on the curves. It was “nosing” too much—swinging from side to side; and they had to stiffen up the lateral springs, to hold the locomotive steady on the pilot truck. About six months after putting the locomotives into service, they had two of them coupled as a double-header out of the Grand Central Station and a bad wreck resulted. Right away somebody said it was on account of bad track. The general manager was arrested on the charge of permitting high speed to be made on unsafe track, but he was acquitted, for it was found that the track was well constructed in every detail. The Pennsylvania R. R., since that time, has been trying something different from the New York Central design; so I think the question of the type of electric locomotive is experimental so far as that road is concerned.

The New York, New Haven & Hartford R. R. has been operating something still different from the other designs. They built a locomotive with two pairs of trucks, on the style of a double-truck street

car, and those locomotives were constructed by a manufacturing concern which had been in the business a long time and had given a great deal of study to the design of locomotives. But they got the wheel base too short, and soon after they were put into operation it was found that the nosing of those locomotives was so strong it spread the rails. For this reason these locomotives have, from that time to this, been under orders for reduced speed until the trouble could be remedied. This they did by putting a pair of idle wheels in the front and rear, to steady the running, which shows that the locomotives were entirely experimental, as far as the wheel base was concerned.

It might be expected that there would be but few electrical defects, but it appears that from the start they have had trouble continually, and they have had to re-design; and in order to defend myself I will read the list of changes and modifications which have been made in those locomotives, as stated by Mr. W. S. Murray, the electrical engineer of the road, in a paper before the American Society of Electrical Engineers this week. Mr. Murray says:

"There were originally purchased 35 locomotives, which was considered an adequate number to take care of the passenger service. These locomotives, considered *per se*, were rated on a half-unit basis. That is to say, the half unit was designed to handle about 75 per cent of our trains, the remaining 25 per cent to be handled by two units. Only a short experience in commercial operation revealed two important facts. The first one was of a very encouraging nature, the second, decidedly otherwise. The first was the proof that the two main parts of the locomotives, namely, the transformer and motors, had sufficient capacity to more than handle the manufacturer's guarantees; the second was the discovery that many of the auxiliary electrical and mechanical parts of the locomotive equipment were not of equivalent capacity. The strength of the chain being measured always by its weakest link, it was seen immediately, that the locomotives would be able to handle trailing loads in excess of their guarantees if the auxiliary parts were made of sufficient capacity to furnish the necessary current for the overload conditions. It was simultaneously apparent that more locomotives would be required to provide for an increase of train service and the reduction of time schedule, and an order was promptly placed for six additional ones. Before accepting their design, however, a careful survey was made of all the component parts of the locomotives at hand, in order to determine the changes necessary to be incorporated in the six new engines. To accomplish this it was found necessary to make a number of electrical and mechanical changes, the nature of which is apparent in the following tabulation:

MECHANICAL

Air Reservoir System, revised.

ELECTRICAL

Ammeters revised.
Battery; charging relay installed.
Blowers; commutator slotted.
Waste rear bearing.

April, 1909

MECHANICAL	ELECTRICAL
Boilers installed.	Armature laminations ground. Bearing raised above center. Motor winding revised.
Stack hood removed.	Controller; bushing riveted; Shoe and trolley switch installed.
Bell Rope installed.	Circuit-breaker fused. Tank bolt secured. New type installed.
Blowers, new design installed.	Compressor; commutator slotted. Armature laminations ground. New governor installed. Bearing raised above center.
Guide on present damper rod.	Cut-out Boxes. New drums.
Extra guard on shutter.	Fuse in alternating current heater circuit. New auxiliary fuse box (wooden).
Bolster, reinforced on truck.	Auxiliary motors separately fused. Grounding switch installed.
Brakes: new release spring.	Control revised. Shutter in cover. Heater switch shield installed.
Cylinder leads lengthened.	Heater bus-bar line; reinsulated. Couplers repaired.
Check nut on adjuster.	Headlight; adjusted properly. Porcelain switch installed. Motors. Holders reinsulated.
Compressor drip pans installed.	New cross-connecting leads. Housing, asbestos lined. Linen tape on commutator end.
Exhaust pipe installed.	Side commutator covers perforated. Perforated S. I. commutator covers.
Air-cooled cylinder head.	Field clamp bolt secured. Motor-generator, new switch.
Check-valve in whistle pipe.	Preventive coils revised. Supporting frame revised.
Gage on oil tank.	Direct-current relay; connection to "—S" switch. Washer installed.
On steam line.	Resistance insulated. Capacity increased. Connected ahead of motor.
Journal-box gibbs revised.	Switch group; revised shunts. Revised studs. Revised arc shields. Copper reverse switches. One-turn blowout coils. Air ports enlarged. Alternating current frames insulated.
Quill-plate washers installed.	Cylinder aligning set screws. Reinforcing wooden strip. Interlocking reverse switches. Fitting alternating current switches.

MECHANICAL

ELECTRICAL

Running-board on roof.

Group covers perforated.
New B. O. coil pole piece alternating current.

Semielliptic springs; 14 leaf.

Switch; block on direct current case.
Main switch connection modified.

Safety-valve on control resistance.

Canopy switch handles insulated.
Shunt remounted. Direct current ammeter.

Safety-chain made heavier.

Trolleys. Control revised (alternating current).

Torque rods, heavy installed.

Side bearing springs (alternating current).
Insulate back cross-rod (alternating current).

Shield for high tension lead (alternating current).

Spring shortened (direct current).
Insulator filled and painted.

Uncoupling lever revised.

Temperature Indicators.

Pony wheels installed.

Third-rail shoes. M. I. bracket.
Pin replaced by bolt.
Jumper installed.
Shoe levers cut off.

Valve on oil line to boiler.

Fuse boxes—refitted.
Wattmeter (Auxiliary) installed.

I want to say that, in addition to existing designs of electric locomotives for fast and heavy service being experimental, there is yet no decided standardization of transmission. We do not know yet whether the third-rail method of transmission, or the overhead transmission, such as the New York, New Haven & Hartford R. R. has adopted, is to be the more desirable. On the New York, New Haven & Hartford R. R. it was found, for one thing, that the hard-drawn copper conductor began to give out after only a few months' service. It began to break or kink at the hanger points and so they have had to install what they call an auxiliary conductor. They tried two kinds: one was a very hard alloy and the other a steel wire. The latter, for various reasons, turned out to be the more satisfactory, and the whole system has now been equipped with an auxiliary steel wire. When you come to consider the third-rail type of transmission, you are involved with great difficulty in providing for transmission in networks of yard tracks.

The railroad companies have been to great expense experimenting with the character of the electric current. The New York Central R. R. uses continuous current and the New York, New Haven & Hartford R. R. uses alternating current. Although the motors of the latter system had been thoroughly tried, the conditions of operation were better understood after practical trial, with the result that they had to rewind all their generator units at great expense, and found that after all, the operation of trains interchangeably, on either continuous or single-phase current, was an experimental matter. While they have

the cars operating with reasonable satisfaction at the present time, I think it is rather too early to say that any such system of operating trains can be considered a permanent thing.

With all the evidence which you have from the electrical engineer of the road, I think it signifies that the electrical operation of that terminal in New York has not been by any means a smooth proposition, and that many features of design are still experimental. I have no doubt but that those two roads will continue to be operated by the present systems there installed, but I wish to say emphatically that I believe railroad managements should go very slow in considering this matter, and I think it is important that they should watch the experiments that are in progress in such installations as they have in New York before deciding to electrify their terminals here.

Here is another question: What are you going to do with the freight terminals? There is no precedent as yet for such work as that; no large freight terminal has as yet been electrified. If the city has the power to compel electrification of the passenger terminals by reason of the so-called smoke nuisance, why not, to be consistent and practical, compel the electrification of the freight terminals also? What would it cost to electrify all the freight terminals in Chicago? That is a question that must be taken into consideration, but the author finds no difficulty with it. He would remove the yards from the city altogether, and handle all the through freight in "common transfer yards" outside of the city.

Here let me state that just outside the city of Chicago there has been built one of the finest layouts of yard tracks in existence, for that very purpose; and that too, has been found very much of an experiment. I refer to the Stickney yards, with which no doubt many of you are familiar. The work is a fine specimen of engineering. There are sixty-six parallel tracks, and the hump yards are three miles in length. Undoubtedly it would handle a large part, if not all, of the switching of the through freight which comes to the city. Still those yards, which represent an investment of several million dollars, have lain there unused for more than five years. It is a failure only from the standpoint that the steam roads have not found it a feasible proposition. Just why this is so, let some of the railroad managements explain. The scheme is a beautiful one, but somehow it does not seem to meet with business success. I therefore question any proposal that freight terminals can at once be removed from our cities.

In regard to rapidity of handling freight at local stations, which the author proposes, let it be said that trains cannot be unloaded at a freight shed any faster than you can get the freight away from the shed. If the streets are so congested that the teams cannot get up to the freight house readily and get away, you are not going to get the freight away from that station very expeditiously.

In regard to repairs for the electric locomotive: The author puts that at 3c. per mile. I want to say that for heavy-duty electric locomotives (with the exception of those on the terminal of the B. & O.

R. R., and I am not sure that those locomotives would answer every purpose) we have no figures on electric locomotive maintenance. I believe there is this which I found from my own experience in street railway work, that after an electric motor gets to be about so old (seven or eight years, say) and has been baked by the high heat which results from operation, there comes a time when it is cheaper to throw it into the scrap pile than to repair it, and there is no reason why that would not apply to the armatures of these heavy-duty locomotives as well as to those of street cars.

With reference to another feature of design, I think very serious doubt may be entertained as to whether an electric locomotive, designed on any of the plans now in existence, with a big, heavy armature on the axle, or with the very slight spring connection, such as can be interposed, will not be so severe on the track as to result in heavy cost for repairs. The weight is mostly down between the wheels, whereas with steam locomotives the great bulk of the weight is on the springs, and it is so high above the track that there is a chance for the load to distribute itself over more than one pair of driving wheels before it reaches the track. I have serious doubt as to whether track maintenance will be anything like as small under electrical operation as under steam operation.

The author states that if anything happens to the electric locomotive, it can be repaired out on the line, whereas if anything happens to a steam locomotive it has to be sent to headquarters for repairs. I do not see how he arrives at that conclusion, nor does he explain how his electrically operated terminals double the capacity. I shall be glad if, in his closure of this discussion, he will give us a little more light as to the basis of these assertions.

CLOSURE.

Mr. H. H. Evans: Criticism has been made that data is not afforded as to the cost of maintenance of electrical rolling stock. While the working of electrical locomotives on a large scale is somewhat recent and comparatively infrequent, those in charge have been glad to publish such figures as there are and to let them stand for comparison against similar figures for steam locomotives. When we come to multiple unit coach equipments, more complete data is afforded from the performances of the elevated railroads and of the suburban and interurban equipments of the character required for the electrical operation of the present steam suburban services. This is extremely pertinent because the logical electrical operation of the suburban service of a steam railroad is by multiple unit equipment of the same general character as that in use by the elevated railroads and with the service operated in the same general way. I may point out that, on two of our terminals the suburban train mileage exceeds all other mileage over the terminal combined.

Taking the 1907 report of the Illinois Railroad and Warehouse Commission, and calculating from the total operating expenses, the
April, 1909

operating expenses per car mile, and the amount of operating expenses charged to maintenance of equipment, we find the following values for maintenance per car mile on electric third-rail roads:

Aurora, Elgin & Chicago.....	1.38 cents per car mile.
Chicago & Oak Park Elevated.....	1.02 cents per car mile.
Metropolitan Elevated.....	1.55 cents per car mile.
Northwestern Elevated.....	1.90 cents per car mile.
South Side Elevated.....	1.41 cents per car-mile.

From the Massachusetts Railroad Commission Report, we calculate for the same, Boston Elevated 1.84 cents per car mile.

Mr. Potter ("Developments of Electric Traction," before New York Railroad Club, January 20, 1905,—quoted in *Street Railway Journal*), gives the maintenance of electrical equipment on the Manhattan Elevated cars as $\frac{1}{4}$ cent per car mile.

Cserhati states that on the Valtellina, from July 1, 1903, to June 30, 1904, the maintenance and repair of rolling stock, including electrical equipment and mechanical parts, was 1.38 cents per *locomotive* mile.

On the Paris-Orleans line, the maintenance and repairs per *train* mile, according to M. Dubois are 2.5 cents per *train* mile; and on the Paris-Versailles (largely multiple-unit trains) 2.4 cents per *train* mile.

On the Mersey road, according to Dawson, the repairs and renewals of "wagons and carriages" per *train* mile were reduced from 3.498 cents to 2.150 cents by changing from steam to electrical working.

Dawson, gives the cost of maintenance of electrical motor cars at 0.961 cent per car mile. This is for a two motor equipment (125 H.P. motors), and represents the maintenance on the car bodies, trucks, airbrakes, air compressor and governor, motors, and multiple unit controlling apparatus.

Based on tests, the repairs on the New Haven electric locomotives is estimated by Mr. W. S. Murray at 2.5 cents per train mile.

The expenses for a New York Central electric locomotive, for inspection and repairs, on a 100,000-mile test run, were 1.26 cents per *train* mile.

The St Louis & Belleville Electric Railway, in a letter to the General Electric Company stated, regarding their electric locomotives, that for an average working of 312 days per year hauling coal and miscellaneous freight, averaging about ten hours per day, the electric-locomotive repairs (for the locomotive performing this work), were a little over \$88.00.

The International Railway Company, in a letter to the General Electric Company, stated that records covering the cost of maintenance of two electric locomotives for three years and eight months, showed a total of \$1,257.56, or an average of \$342.96 per annum. This is \$171.48 per annum per locomotive. The letter states that the locomotives make an average of 100 miles per day for seven days in

the week and are out of commission for repairs about five days a year. This figures less than $\frac{1}{2}$ cent per *locomotive* mile.

The unfavorable comparison between the electric and the steam locomotives of the Baltimore & Ohio R. R. made by Mr. Muhlfeld, has been brought up. The comparison is hardly a fair one. The Baltimore & Ohio installation was the first heavy electric locomotive installation in the world. The machines could not be other than experimental. At the time they were built, electrical design did not run to its present day simplicity nor did it keep always in sight the building of machines in which the maintenance would be kept to a minimum. To compare the earliest type of electric locomotive with the latest type of economical freight engine is hardly fair upon its face. Further, these electrical locomotives are operated within tunnels, on a run only 3.5 miles long, up-grade, with seven curves in the distance, and with two intermediate stops. The tunnels are foul with the gases from the locomotives at the heads of the trains, the corrosive action of which gases was so severe that they rapidly deteriorated the overhead conductor at first provided and compelled the substitution of a third rail therefor. What must their effect be upon the repair bills of the electric locomotive? The service is really switching service under severe conditions and is not at all comparable to the service of a carefully groomed engine over an entire division with hardly a stop. Furthermore there are only half a dozen electric locomotives at Baltimore for which a separate maintenance plant was provided. These locomotives are not all of the same type. The cost per locomotive to maintain such a plant in operation, is necessarily much beyond the cost per locomotive to maintain the large plants for steam locomotives at the end of divisions. This is independent, in a degree, of whatever class of rolling stock is cared for. It comes nearer to a showing of the relative economy of maintenance in small and in large plants than the relative economy in maintenance of the two classes of locomotive.

When we come to compare operating costs, the figures again, are hardly on a fair basis. The Baltimore & Ohio R. R. electric locomotives are operated on a grade as steep as is acceptable for mountain divisions on low grade freight roads. The electric locomotive has almost a stop and a full acceleration in each mile. The power required for such acceleration per train mile is so far in excess of that required per train mile to maintain movement over a long run without stops, that a simple statement of the cost of fuel per ton mile moved (or of other expenses on a similar basis) is entirely misleading. I may further add that the cost of power at Baltimore is high of necessity. Only one locomotive is worked at a time and the load is a succession of blanks and peaks. The power house is antiquated and the storage battery run down. A part of the engines are high speed engines and they operate upon atmospheric exhaust. Further, since Mr. Muhlfeld prepared his paper I have been assured, upon a visit to Baltimore, that economies have been effected both in operation and maintenance

by certain changes in the machinery and a different system of handling repairs to the electric locomotives.

There is advanced a criticism that electric motive equipment has not been in service long enough to test its durability. The various elevated railroads have in service equipment that was provided upon their electrification ten to twelve years ago. The original Baltimore & Ohio R. R. locomotives (built 1895) are still in service. The first electric locomotive built by the General Electric Company (in 1894), I understand is still in service by the Fonda, Johnstown & Gloversville Railroad, the successors to the Cayadutta Electric Company, the original purchasers. Except the Central London locomotives (scrapped in favor of motor coaches to reduce vibration over a tube road) little heavy electric motive equipment has required to be scrapped. That equipment is still good for service after twelve to fourteen years use, is reassuring as to its durability.

I wish to say in connection with the smoke nuisance, that our statements to the City that the vegetation in Grant Park was killed by the Illinois Central smoke were made only after communication with the South Park Commission by whom we were informed that it was next to impossible to make trees and shrubbery live in Grant Park near the railroad and that they ascribed it to the smoke from passing trains.

As to property values along the right of way of the Illinois Central road, my information came from property owners in the vicinity who have both sold and bought property in recent years. Most Chicago property fell in value after the World's Fair but the depreciation along the Illinois Central was not followed by a recovery in the same proportion that came to the city generally. My informants give as the reason for people moving out of the territory, or for people offering lower prices for property, that the railroad smoke is objectionable to near by dwellers. Nobody denies that the Illinois Central in its early days did a great deal to build up the district. But since then more attractive means of local transportation have developed and the people would like to see the suburban service maintained at a progressive standard. To ask why the operation of steam train has become objectionable to a district, which some maintain was created by those trains, is to lose sight of the fact that while the trains of a railroad may make a community, their growth in number may mar that same community. The trains supplied at first, afford a large convenience which overshadows a small nuisance. Later trains only add a little in proportion to the convenience but they multiply the nuisance.

In answer to the criticism of my proposition for intensive working of freight terminals, loading the freight into cars and removing it to outer yards as fast as the wagons deliver it, I would like to point out that the largest railroad freight terminal in the city of London, in point of freight handled, is so worked and very successfully. To insure wagon delivery at the proper time however, it became necessary for the railroad to undertake the teaming both for collection and

delivery of freight. Private wagons are not allowed at the terminal except under certain conditions.

I would like to point out that the \$30,000,000, given as the cost of the New York Central electrification includes more than the electrification proper. Extensive terminal changes were carried out at the same time. The purely electrical work probably came to a third of the sum.

In conclusion, the \$4,000,000 estimated as the cost of electrifying the Illinois Central terminal (not including the power house) is not intended to represent the highest cost at which an equipment could be provided. It is simply a figure at which satisfactory equipment could be provided for present needs. It makes no provision for future growth of traffic, which future growth should be provided for. It contemplates many economies such as the use of an overhead trolley with wooden poles over tracks in yards which are seldom in use, and the equipping of the present suburban coaches with motors instead of supplying new motor cars. Without wanton extravagance the expenditure might be trebled in the interests of permanent construction, provision for future growth, and of safety. But as present traffic alone was considered, it was deemed best to provide for present needs alone in a satisfactory but economical manner and to leave out all speculation as to future development with elaborate provision therefor.

MANGANESE STEEL

W. S. POTTER, PATERSON, N. J.

Presented February 17, 1909.

The subject of my paper this evening, as you know, is manganese steel. During the past four years I have spent most of my time in working this steel, and in the four preceding years I did a great deal of work on the same metal, partly commercial and in part experimental.

There is a growing appreciation for this metal, and I think it is time that the engineering fraternities should get together as you have done tonight, and try to establish the fundamentals on the subject of this steel, for, although it has been much talked about it has not been well understood.

Definition:

Manganese Steel usually means a metal of the following composition:

Manganese	11.	to	13.	%
Carbon	1.	to	1.20	%
Silicon	0.25	to	0.40	%
Phosphorus	0.06	to	0.11	%
Sulphur	0.02	to	0.06	%
Balance of analysis Iron.				

So many variations in composition have been tried, or have been accidentally manufactured, that this steel can only be defined correctly as a steel high in manganese. It might be stated that the manganese content must lie between about 8% and about 35%.

The lower limit of manganese in steel which would be recognized as manganese steel is determined by the fact that alloys having between $7\frac{1}{2}\%$ and $5\frac{1}{2}\%$ of manganese are extremely weak and brittle and that the characteristic strength and toughness can only be given to steels having more than 8% of manganese.

The upper limit of manganese in manganese steel is determined partially by the cost of manganese metal which is about 50 cents per ton unit, when the addition is made by means of ferro-manganese. Also the high carbon content of ferro-manganese interferes with the physical properties induced by the manganese. When enough ferro is added to make a steel with manganese 20%, the carbon begins once more to dominate and a steel results which is stiff and brittle when cold, and unworkable when hot.

In the table below a comparison is made between the physical values of six steels of which three contain manganese 11%, three with manganese 13%, and with each percentage of manganese

one specimen has carbon 0.12, one has carbon 1.%, and in one the carbon is 1.60%.

	C-1	C-2	C-3	D-1	D-2	D-3
Manganese...	11.%	11.%	11.%	13.%	13.%	13.%
Carbon	0.12%	1.%	1.60%	0.12%	1.%	1.60%

C-1 and D-1 are not at present commercial since they require the use of carbonless manganese metal. C-3 and D-3, although perhaps fairly good in a cast crusher jaw, could not be worked hot.

At present commercial manganese steel has a comparatively narrow range of analysis.

Steels containing manganese from 9.% to 11.% are very good and it may be found in rails, for example, that steel containing from 10.% to 11.% manganese, and with a suitable proportion of carbon, will have higher elastic limit than steel containing over 11.% of manganese.

With carbon low, manganese high, and water quenching from about 1000 deg. Centigrade, the elastic limit is low, and the flow excessive for many duties.

Steels containing manganese about 11.% and carbon 1.10, for example, have a higher elastic limit than steel with manganese 15.% and carbon 0.80%. Before deciding that steel containing less than 11.% manganese would be most desirable for rolled rails it should be remembered that the peculiar merit of manganese steel in resisting abraasive wear results from the combination of strength and ductility. The most ductile steel which has at the same time a sufficiently high elastic limit to avoid distortion in the service for which it is intended will be the best in each case. Many mixtures have been experimented upon containing such ingredients as chromium, tungsten, molybdenum, nickel, copper, vanadium, titanium, aluminum and other metals. Some very good results have been obtained and notably in cases of small additions of chromium and vanadium. Both of these metals raise the elastic limit without serious loss of elongation or shock resistance. So that for the present, at all events, it is safe to define commercial manganese steel as a steel containing about 11.% manganese, 1.% carbon, and with or without small additions of chromium.

PHYSICAL PROPERTIES.

Hardness.—On the scleroscope scale bessemer rail shows hardness of about 30, Manganese steel shows hardness of 40 to 50, chilled cast iron 65 to 75.

Cold chisels of carbon steel, drawn to the blue, chip manganese steel, while cold chisels made of manganese steel do not hold their edge in chipping bessemer rail. Cold chisels made from bessemer rail, not hardened or tempered, chip bessemer rail as readily as a chisel made of manganese steel.

Manganese steel has usually been defined as a very hard and

tough metal. As demonstrated, manganese steel is only moderately hard but is rather very strong and tough. The confusion between the apparent hardness and actual great strength has arisen from difficulty experienced in drilling and machining this steel.

The supposition that manganese rails will cut or grind steel tired or chilled iron wheels is entirely wrong.

Specific Gravity.—The specific gravity of manganese steel ingots is nearly the same as the result obtained by the usual method of determining specific gravity with chemical balance on a small specimen of cast steel. The rolled steel is slightly heavier. I would say that the weight per cubic inch of manganese steel is about two-thousandths of a pound greater than the weight of a cubic inch of low carbon steel.

Specific Heat.

Ranges from 0.145 at ordinary temperatures to about 0.20 at 1200 deg. C.

Heat Conductivity.

Has not been properly determined but between ordinary temperatures and 600 deg. C. appears to be about one-third that of low carbon steel.

Magnetic Properties.

A bar of manganese steel balanced on a knife edge remains in balance when acted upon by the field of a very powerful electro-magnet. An electro-magnet which would lift two tons of soft steel, when laid upon a block of manganese steel gives so small a pull that the hand recognizes no increased weight in lifting the magnet.

A coil passing a current and acting as a solenoid on a bar of manganese steel develops no magnetic quality.

Very thin cuttings of manganese steel are not lifted by a strong magnet but if these cuttings are hammered into very thin foil they may then be lifted by the magnet.

From these considerations it would appear that this steel might be used to advantage about motors and generators, in a crank shaft, for example.

Electric Conductivity.

Has been determined carefully on manganese steel rails in comparison with bessemer rails, and the resistance of manganese steel rail averaged 3.4 times resistance of bessemer rails. At temperatures between 100 deg. C. and about 600 deg. C. the electrical resistance remains nearly constant. Tests are now being conducted to determine the value of the steel in resistance grids.

Strength as affected by temperature.

This steel melts at about 1330 deg. C. or about 190 degrees below dead soft carbon steel. Below +395 deg. C. and above—190 deg.

C. the steel seems to have nearly the same strength, toughness, shock resistance and hardness as at ordinary temperature.

Coefficient of Friction.

A series of tests were made on the brake shoe testing machine of the American Brake Shoe & Foundry Co. to determine the coefficient of friction between chill cast and steel tired wheels and bessemer and manganese steel rails. It should be noted that this method of determining the coefficient of friction is only indicative of the values which could be expected in case a practical test were made to determine comparative tractive force with a locomotive resting upon manganese and bessemer rails. It will be seen from examination of attached report of tests that when a total pressure between rail and chilled iron wheel was 3,000 lb. the coefficient of friction was greater between the bessemer rail and the wheel than between a manganese steel rail and the wheel but that in all other cases the coefficient of friction was much greater between the wheels and the manganese rail than between the wheels and the bessemer rail.

The rails tested were sections of Manganese and Bessemer steel, 85 lb. rails, approximately $12\frac{1}{2}$ in. long. These sections were curved to give applied surface of the rail a $16\frac{1}{2}$ in. radius, to fit a 33 in. carwheel. The bottom of the rail was turned up on the ends, for an endstop, and in the center for a lug, as nearly an MCB brakeshoe back as possible.

The sections of rails were tested on a brakeshoe testing machine at 20 M. P. H. and under pressures of 3,000, 4,000, 7,000 lbs., on both a chilled and a steel tired wheel, the latter being a bald wheel. Both wheels were 33 in. diameter.

The rails were given three applications at each load on each wheel, and the averages of these three tests were taken.

The rails became slightly warm during each test but were cooled after each application.

The description of the brakeshoe testing machine is as follows:

Mounted on a single shaft, approximately 13 ft. long, is the armature of a 75 H. P. variable speed A. C. induction motor, a steel-tired fly-wheel and a carwheel (which may be changed at will), the whole weighing about one-eighth of a standard eight wheel passenger coach. Over the car wheel is mounted a pivoted breakhead, secured by uprights and fastened to a dynamometer by two pull rods. When a brakeshoe is inserted in this head, the wheel brought up to the desired speed, and the shoe applied under a pressure through a series of levers, all the pull of the shoe on the wheel in stopping it, is transmitted through these rods, to a calibrated spring which in turn displaces a recording pencil, every inch displacement of which indicates a thousand pounds pull on the wheel by the shoe. The time of the stop is recorded by an electric clock and magnet and the length of stop is determined by the length of the diagram.

This latter may be checked by a revolution counter giving the revolutions of the wheel after the shoe is applied.

The motor is, of course, shut off after attaining the desired speed and before applying the shoe.

The bearings of the machine are large and well oiled, thus reducing outside friction to a minimum.

Tests on Chilled Wheel at 20 M. P. H.

3000 lbs. Pressure.	Manganese No. 1	Bessemer No. 2
Time of stop	27 sec.	21 sec.
Length of stop	412 ft.	340 ft.
Mean pull	543 lb.	623 lb.
Mean coefficient of friction	18.17%	20.73%
Area of rail in contact with wheel ...	2.14 sq. in.	1.42 sq. in.

4000 lbs. Pressure.

Time of stop	18.5 sec.	17 sec.
Length of stop	273 ft.	272 ft.
Mean pull	736 lb.	502 lb.
Mean coefficient of friction	18.39%	12.06%
Area of rail in contact with wheel ...	4.27 sq. in.	2.58 sq. in.

7000 lbs. Pressure.

Time of stop	14 sec.	11 sec.
Length of stop	222 ft.	181 ft.
Mean pull	1128 lb.	822 lb.
Mean coefficient of friction	16.11%	11.19%
Area of rail in contact with wheel ...	3.35 sq. in.	2.78 sq. in.

Tests on Steel Wheels at 20 M. P. H.

3000 lbs. Pressure.

Time of stop	22 sec.	21 sec.
Length of stop	348 ft.	331 ft.
Mean pull	736 lb.	448 lb.
Mean coefficient of friction	24.53%	14.19%
Area of rail in contact with wheel ...	4.3 sq. in.	5.14 sq. in.

4000 lbs. Pressure.

Time of stop	17 sec.	15 sec.
Length of stop	265 ft.	245 ft.
Mean pull	833 lb.	694 lb.
Mean coefficient of friction	20.81%	17.36%
Area of rail in contact with wheel ...	6.59 sq. in.	5.27 sq. in.

7000 lbs. Pressure.

Time of stop	11.5 sec.	10 sec.
Length of stop	190 ft.	170 ft.
Mean pull	1206 lb.	1120 lb.
Mean coefficient of friction	17.23%	16. %
Area of rail in contact with wheel ...	6.6 sq. in.	7.51 sq. in.

Tensile Tests:

The early papers of R. A. Hadfield mention tensile tests of forged specimens of manganese steel showing tensile strength about 150,000 pounds per square inch, and elongations as high as 50%. The values found on the best specimens of manganese steel obtainable from various sources, in an exhaustive series of tests conducted several years ago, showed tensile strength of the cast metal averaging about 82,000 lbs., elongation 30%, elastic limit 45,000 pounds. The rolled specimens tested at the same time averaged tensile strength 135,000 pounds, elongation 35%, elastic limit 60,000 pounds. Forged specimens averaged tensile strength 142,000 pounds, elongation 38% and elastic limit 55,000 pounds.

Although considerable progress has been made in the manufacture of manganese steel during the last three years, these values are still approximately correct on good specimens of cast, rolled and forged steel prepared by commercial methods.

It is well understood that the great difficulty in preparing test bars from rolled or cast shapes of manganese steel interferes very seriously with efforts to arrive at standard values on the physical properties of this metal. If the specimens are cut hot from the castings or the rolled shapes the effects of heat treatment and work are entirely lost and the physical properties will be determined almost entirely by the heat treatment and work applied to the test bar.

It is out of the question to grind cold from rails, for example, a sufficient number of test bars such that the tests on these bars will properly represent in every respect the rails, even from one heat of steel. Conclusions based on the testing of finished product is more satisfactory than conclusions reached by the cutting and testing of small bars. I therefore attach a printed copy of a report made by R. W. Hunt & Co., which gives the results of drop tests on twelve rails, which were taken from twelve different heats.

As previously stated the elastic limit of manganese steel can be raised considerably above the traditional values by introducing a small quantity of chromium and other elements and more particularly by properly heating and working the metal.

From tests and experiments made it appears that tensile strength of commercially rolled manganese steel will generally lie between 135,000 and 140,000 pounds, elongation between 30 and 40%, and elastic limit will usually lie between 60,000 and 70,000 pounds. In many instances, however, the steel of ordinary composition shows an elastic limit of about 75,000 pounds, and in a few cases where chromium and other elements have been added, the elastic limit has been as high as 85,000 pounds. Tensile strength and shock resistance do not seem to be lowered by chromium when the steel contains up to about 1% of chromium. The elongation is very rapidly lowered when chromium is above about 0.50%, so that when chromium is above 1% the elongation is below 20%.

Abrasive Wear Values.

The well known high abrasive wear value of manganese steel seems to depend upon its ability to flow and endure repeated distortions of the wearing surface without surface fractures, which would result in the constant loss from the surface of small pieces.

A good illustration of this property of resisting loss in weight is to pound a square corner round and then pound it or pean it up to a sharp square corner again and repeat until metal on the corner of the rectangular block begins to give way.

Manganese steel endures much more of this very severe treatment than any other steel.

On account of this property manganese steel resists abrasive wear which is of the character of heavy impact of hard substances better than it resists abrasive wear which is of the character of sliding attrition of hard particles, or wear which is like the action of an abrasive wheel.

The screen or plate receiving ore or crushed stone from a height of several feet will be worn out, if of soft steel, in a time as short as 1/80th the time required to wear out the manganese plate. The same materials sliding in such a manner as to avoid impact may wear out the manganese plate in a time only five or six times as long as that required to wear out the carbon steel.

HEAT TREATMENT.

Upward of 75 years ago men in Sheffield, England, understood that steel containing moderate additions of manganese had **certain** properties which could be described as those of carbon steel, and that steels containing a higher percentage than 5% or 5½% were very weak and brittle.

Some thirty years ago the Hadfields, father and son, or their associates found, and the son advertised the fact that castings and forgings containing the higher percentages of manganese, after heating to a high temperature and quenching in water, were very strong and tough and that the treated steel had remarkable resistance to abrasive wear. The proportion of manganese mentioned as suitable for track work castings, in Hadfield's early patents is 11%. No heat treatment was mentioned in the early papers, but later a treatment was announced and consisted in heating the casting at first slowly and then rapidly to 800 deg., 900 deg., or 1,000 deg. C., and immediately quenching in water. No theory covering the necessity of this reheating and quenching was given.

Manganese steel of ordinary composition poured in a layer about ¼ in. to ½ in. thick in a chill mould will, when cold, bend double, and has all the usual toughness of reheated and quenched manganese steel. Castings from the same ladle of steel poured in sand moulds have a toughness approximating the toughness of the reheated and quenched metal in inverse proportion to the thickness of the sand cast

section. For example a sand cast section $\frac{1}{2}$ in. thick will usually bend from 45° to 90° before it breaks by cold bending. A section 2 in. thick usually breaks in cold bending, before it is deflected as much as 20° . The thinner section is whiter and has smaller crystals than the heavy sand cast section, and the chill cast section is still whiter and has still smaller crystals than the thin sand cast section. The three specimens heated to 1,000 deg. C. and quenched in water exhibit in each case a very remarkable and practically equal degree of toughness. In all these cases the steel has practically the same hardness. The chill cast specimen before reheating is the hardest, the sand cast specimens are slightly softer and the reheated and quenched specimens are the softest. If the specimens are now heated to 700 deg. C., or even a little lower temperature, held for, say one half hour at this temperature, and cooled slowly to ordinary temperature and broken, they are surprisingly weak, and as a rule, bend but slightly before breaking. The crystals are very large and it is obvious that no strong cementing materials are present to bond the crystals. A section 3 in. thick cooled slowly from the heat of casting, and put under a drop weight will break about as readily as an equal thickness of a fair quality of grey iron and will frequently show crystals with a mirror surface as large as $1\frac{1}{4}$ by 1 in. For the most part such a section so treated and broken will show crystals about $\frac{1}{4}$ in. to $\frac{3}{8}$ in. on a side. A specimen heated to above 700 deg. C. and cooled slowly to below 600 deg. C., is very weak. If this specimen is reheated to 700 deg. C. and quenched in water only a slight increase in toughness is noted. The crystals are still apparently as large as ever. The bond between the crystals is almost as weak as before, and yet from the other tests it is clear that the steel crystallizes or re-crystallizes considerably below 700 deg. C.

Comparing this steel with a carbon steel it is obvious that the cementing materials are not taken into solution at as low a heat in the manganese steel as in the carbon steel. In the carbon steel, the size of crystals, strength, toughness, etc., may be re-determined any number of times by reheating to 700 deg. C., and cooling, and as is well known, the physical properties are governed by the rate of cooling.

The manganese steel after being put in a weak condition due to slow cooling from 700 deg. or above is only put in a condition of maximum toughness by reheating to a much higher temperature and then cooling rapidly enough to prevent either mechanical or chemical separation.

A comparison of *color* carbon tests with determinations of total carbon by combustion, shows that the slow cooled steel has a much smaller amount of carbon in the condition which permits of the determination of carbon by color than the manganese steel which has been rapidly cooled.

The highest color result is obtained from the thin chill cast section, the next highest from a specimen heated for a short time only and

quenched in water. The lowest carbon result (by *color* test) is found in the specimen which has been heated to a high temperature, maintained at this temperature for some time and cooled very slowly. The chill cast specimen showing by total carbon determination 110 points carbon, by *color* test may show 105 to 108 points. The specimen annealed at a high heat will give color results ranging from 0.60 to 0.95%, depending upon the time to which the specimen was exposed to the highest temperature, the rate of cooling, and the percentages of manganese and silicon.

As might be anticipated from the general knowledge pertaining to the art of "black heart" malleable iron manufacture, the percentage of silicon plays a very important part in the decomposition of carbides of iron and manganese in manganese steel.

Manganese steel is readily burned when heated, and this burning is more difficult to avoid as the temperature is higher. For this reason it is usual to heat for quenching only to a point sufficiently high to give the characteristic toughness in the quenched metal.

If castings or other finished shapes are reheated for toughening to a high temperature they are apt to be very generally affected with deep cracks. To avoid burning and cracking the reheating is generally stopped at about 1,000 deg. C.

ROLLING.

So far as I am aware the only Manganese Steel rails rolled commercially up to the present time have been made according to my process and I regret that I am not at liberty at the present time to discuss the details fully. Certain interesting and important facts however, have been demonstrated, which I may explain.

A very small ingot rolled with small reductions in each pass to a seven-eighths inch square and worked until at about 600 deg C. was cooled in the air on an iron floor and bent 180° around a radius of ½ inch without checking or cracking. The bar had a maximum strength and toughness and the color carbon test was within two or three points of the determination of carbon by combustion.

A large ingot however rolled to a section such as the head of a rail, and finished at 700 deg. C. and then cooled in the air, left the metal in a coarsely crystalized weak and imperfect condition. In order to make this larger section of proper strength and ductility it is necessary to reheat and quench in water. This reheating will inevitably remove the excellence due to work and there will always be a doubt as to whether the rail has not been burned or cracked in the reheating prior to the quenching.

A stiff mill will roll small sizes from a heat as low as 1000 deg. C. and a heavier mill would, of course, roll larger shapes, beginning with the same temperature.

Theoretically a specially constructed and very heavy mill might

roll a rail beginning at 1000 deg. C and ending at 700 deg. or above. But before the temperature has fallen as low as 700 deg. C. the steel is so stiff that only very slight reductions and alterations of forms can be executed in one pass in the rolls of an ordinary mill.

In a rolling mill of the American type where the power and strength of the mill is at a commercial maximum, and the time in rolling between the soaking pit and the hot bed is frequently less than five minutes, the drop in temperature is usually about 900 deg. F. or about 500 deg. C. and it is clear that in such a mill, manganese steel ingots heated in an ordinary manner could not be rolled beginning with a temperature of say 1025 deg. C. and under, and ending the work with a temperature of the finished rail as high as 700 deg. C. If the rail is finished too cold, as previously stated, the work is excessive, and the steel is very uncertain as to quality. On the other hand, an ingot or bloom heated to a high heat and burned or cracked in the heating will crush in the rolls and no rail will result.

If a cast bar, for example a round bar 1 in. in diameter, is heated carefully to a red heat to avoid cracking due to strains, then plunged in a bath of melted grey iron or melted copper, then withdrawn and examined by bending, it is found to be very generally affected with cracks which extend from the skin to the center of the bar. The piece then breaks exhibiting a surface along the line of one of these cracks, and shows a peculiar columnar fracture.

A piece of cast manganese steel heated in an ordinary manner in a heating furnace to a temperature much above 1000 deg. C., removed from the furnace and tested cold, either with or without quenching, exhibits these cracks and this peculiar fracture. The steel is easily broken in heating to temperatures above 1025 deg. C. or thereabouts.

Exhibits E and E-1 show first a granular or nodular surface, the result of crushing a large ingot of manganese steel in the blooming mill at points and along lines where no cracks existed, and also a columnar fracture which was caused by improper heating. These are failures which must be avoided if manganese steel is to be rolled and a good reliable product made.

A rolled shape is finished at a temperature higher than would be the case if a specimen of carbon steel were similarly heated and worked, because the specific heat of manganese steel is considerably higher than that of carbon steel and its coefficient of conduction is very much lower.

By my process of rolling manganese steel the steel is ductile while hot, and can be rolled commercially; the steel is not injured either by burning or cracking, and the product is tough and reliable, has a uniformly fine crystalline structure, and a much higher elastic limit than if rolled and finished in any other manner which I have tried. This process which at present is used only by the Manganese Steel Rail Company and is entirely my own invention.

SPECIFICATION FOR ROLLED MANGANESE STEEL RAILS.

As specifications for manganese steel rails are likely to be written in the near future I beg to submit the following points as suitable for incorporation:

Rails from any heat to withstand the standard drop test of the American Maintenance of Way Association.

Tensile Test Bars.

Cut cold from head, web and base of rail to give tensile strength above 100,000 lb. Elastic limit above 55,000 lb., elongation above 20%.

Bending Test.

Flat strips cut from head, web or base of rail to bend 180° around a diameter twice the thickness of specimen without evidence of failure and at temperature between ordinary atmospheric temperature and —60° F. This will insure the toughness which determines wear value.

Manufacture.

Composition to be:

Manganese	10.%	to 13.%
Carbon	0.95%	to 1.15%
Silicon	0.20%	to 0.40%
Phosphorus	under 0.10	
Sulphur	under 0.06	

Ingots to be cast of weight sufficient to produce four 30 ft. rails from an ingot and in such a manner as to be free from pipes. Rails to be rolled to finished size from ingots in not to exceed three heats including the heat of casting.

Rails not to be reheated after rolling.

Finished rails to meet standards of American Maintenance of Way Association as to smoothness, dimensions of section, etc.

EXHIBITS.

	Carbon by Combustion	Manganese
A-1	0.71%	4.77%
A-2	0.66%	5.40%
A-3	0.85%	6.16%

Steels like A-1 and A-2 and containing manganese from 4% to a little upwards of 5%, and with carbon up to 2% may be rolled, but are very stiff in rolling. The product is a very stiff steel having many of the properties of an air hardened steel. The carbon here dominates the physical properties.



Exhibit A-1

Specimen A-3 has a comparatively innocent looking fracture, but on close examination it would seem to have a peculiarly glassy shine. The manganese contents of this specimen is 6.16. Steels having from about 6 to 7% manganese have this peculiarly glassy shine,

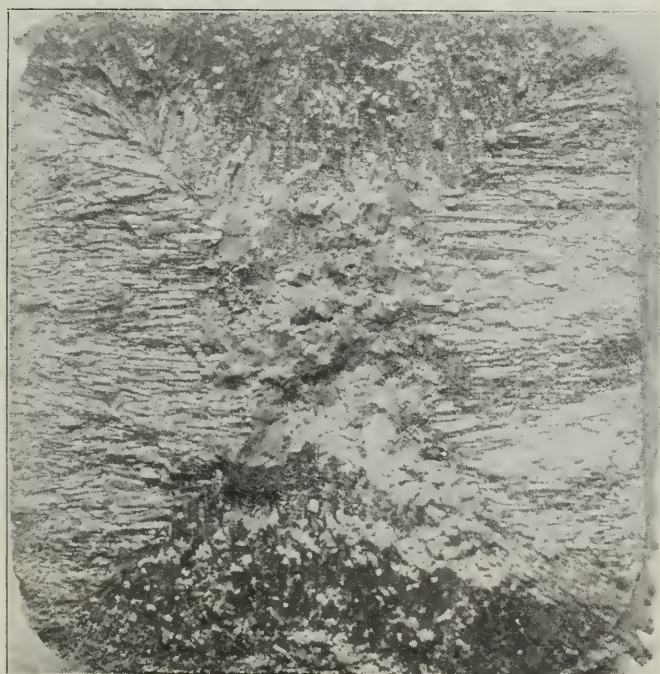


Exhibit A-2

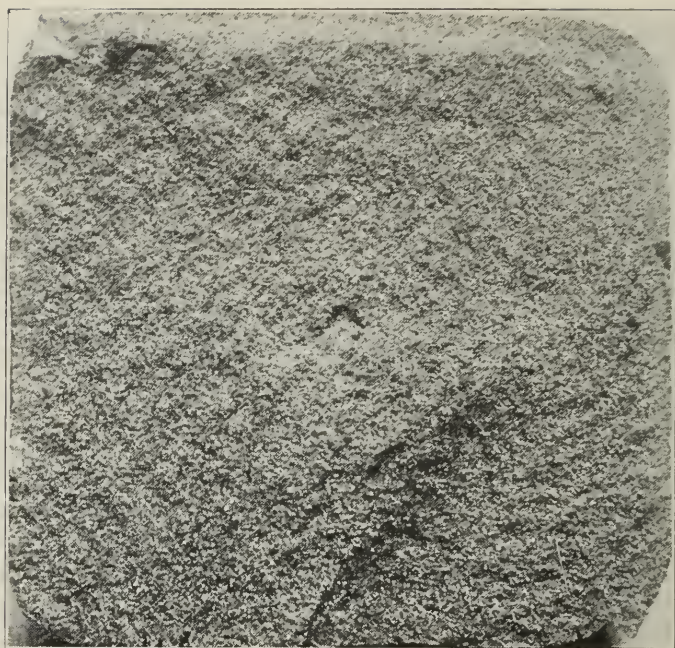


Exhibit A-3

and as a rule much larger crystals, and are generally much weaker than this specimen, which was broken by the drop of a 1,500 lb. weight at a height of 10 inches. This specimen is an example of

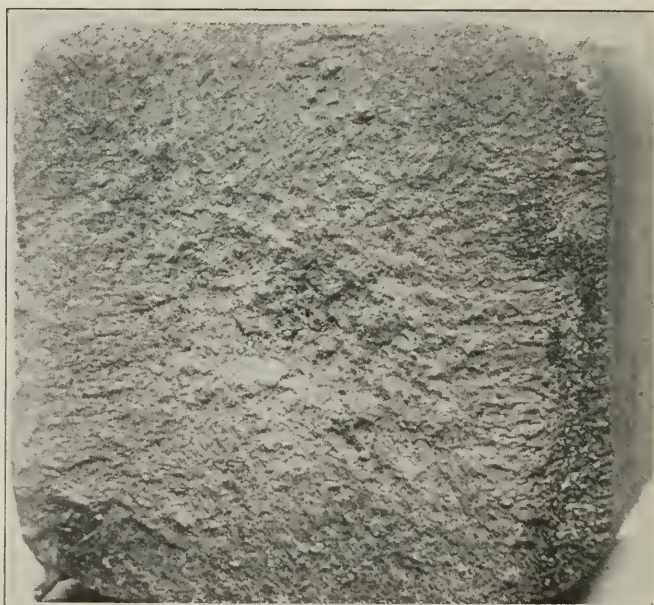


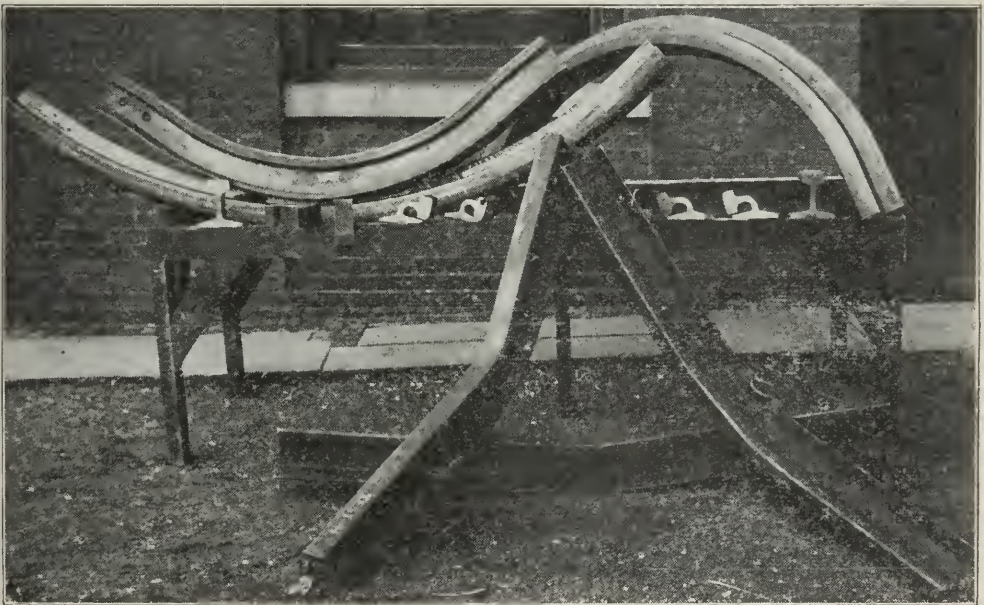
Exhibit B-1

the transition stage between steels containing manganese which are dominated by carbon and steels containing higher percentages of manganese which are dominated by manganese. The hardness is

here in maximum and is much greater than the hardness of steels either below 5 or above 8 per cent in manganese.

B-1 is an example of steel containing manganese 20% and carbon 2%. It is moderately hard and weak, but still strong as compared with either A-1, A-2 or A-3, which average about one-fourth as much manganese. The weakness which is found in this specimen B-1 is clearly due to excess of carbon.

*D-1.** Here is an example of cast steel containing manganese 13.25%; carbon 1.82%. Manganese is normal for manganese steel, and the steel would have been tough after the treatment if the carbon had been less, under 1.30%, for example. The heat treatment was repeated the second time and still the casting could not be deflected appreciably. Under a drop weight before the failure occurred a small piece cut from this casting was forged into the small bar shown. Although the forging was accomplished, it could hardly be said that steel of this composition could be forged or rolled commercially. This steel was brittle at 550 deg. C., and was very weak above 1,100 deg. C. After forging, the bar was quenched in water and then was bent as shown. If the carbon had been 1%, for example, these specimens should have bent 180 deg. and might even have been straightened out again before it could be broken. We have here a very nice point: Manganese steel can be forged after the carbon has been raised so high that the steel is practically valueless.

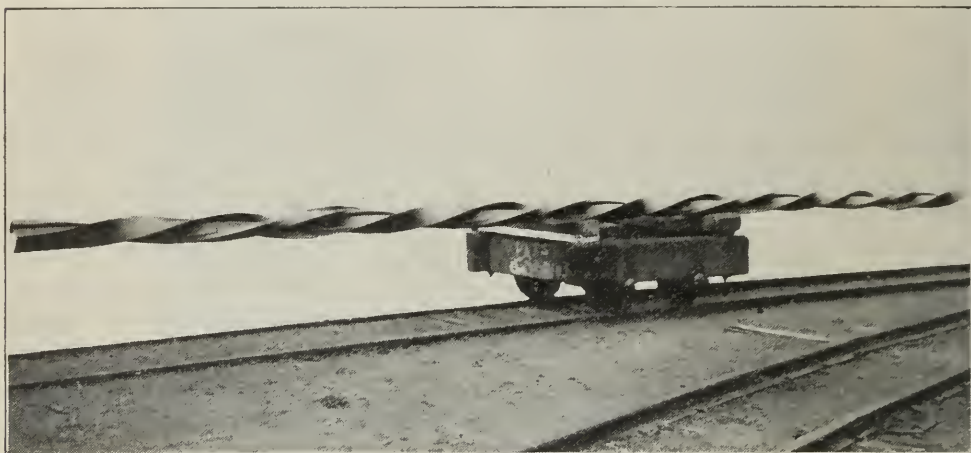


I

Illustration 1, shows a group of rails bent cold vertically and

*The illustration of this specimen was not available for reproduction, as with the preceding specimens.

laterally in a gag press or under a drop weight and a few short sections of rail which have been bent under a steam hammer sidewise so that the head touches the base of the rail, in all cases without evidence of fracture.



2

Illustration 2, is a 28 foot length of an 85 lb. A. S. C. E. rail twisted cold in a roll lathe, four complete turns without developing any sign of failure.



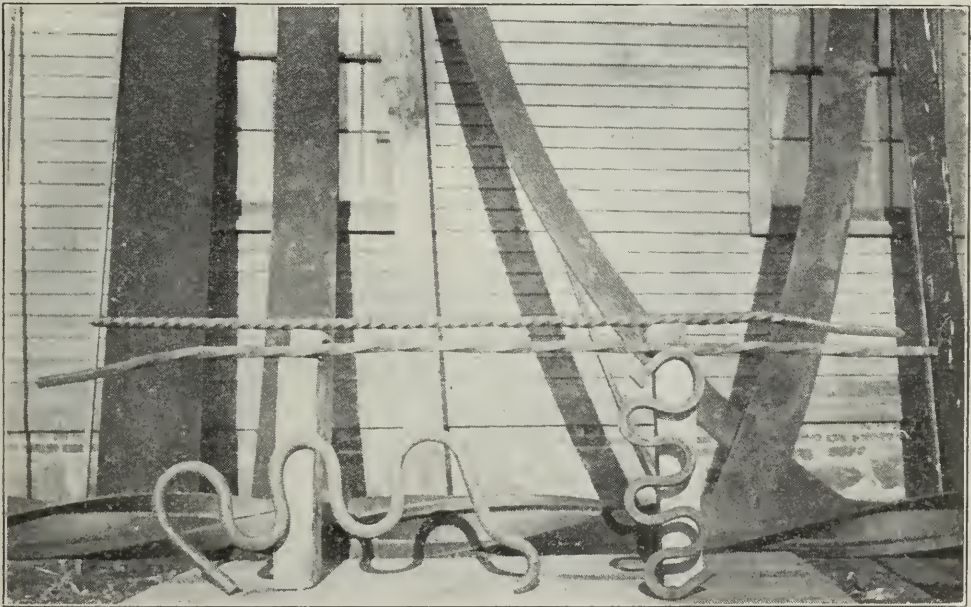
3

Illustration 3, shows a rail broken under a heavy breaker ball. The fracture shows a very even, fine crystallization, and the force required to break the rail was far in excess of any standard test on rails. The last blow was a forty foot drop of a 5,600 lb. weight.



4

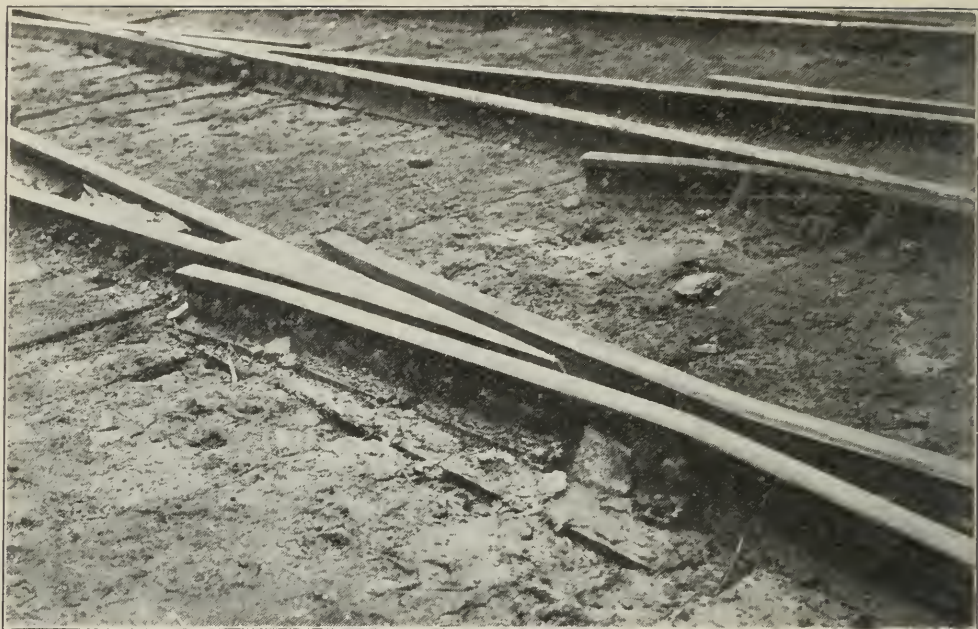
Illustration 4, shows various sizes, blooms, rounds, squares and plate which have been rolled in ordinary mills.



5

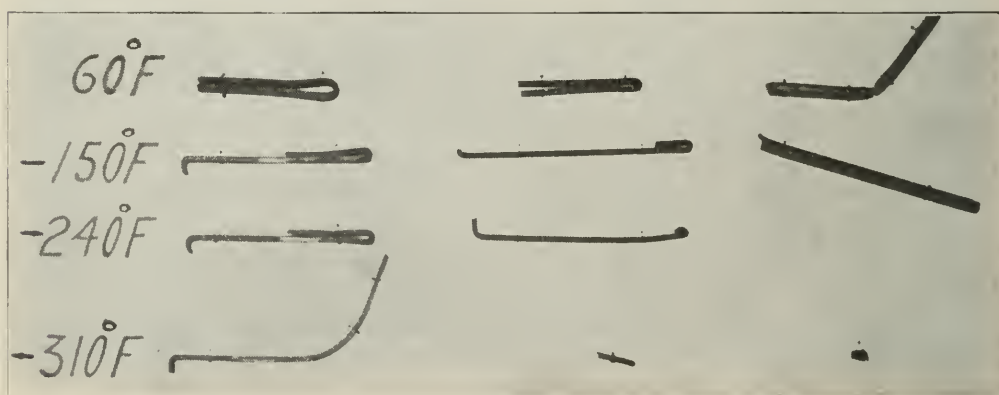
Illustration 5, shows some twisted bars and several widths of rolled plate. The smallest bar horizontally in the center of the cut was twisted in a lathe twelve complete turns without sign of rupture.

April, 1909



6

Illustration 6, is a frog which has been in service long enough to outwear two and one-half Bessemer rail frogs on the same crossing. The wing rails and the heel rails are rolled manganese steel, the point is a manganese steel casting. The point is holding up finely, but shows more wear than the heaviest wear on the inner rails opposite the point. There is no sign of shelling off from the surface of either the rails or the casting. There is no flow on any of the bars to make a burr, or even along the edges of the wearing surface. There is no reason to doubt that this frog will outwear twenty Bessemer rail frogs.

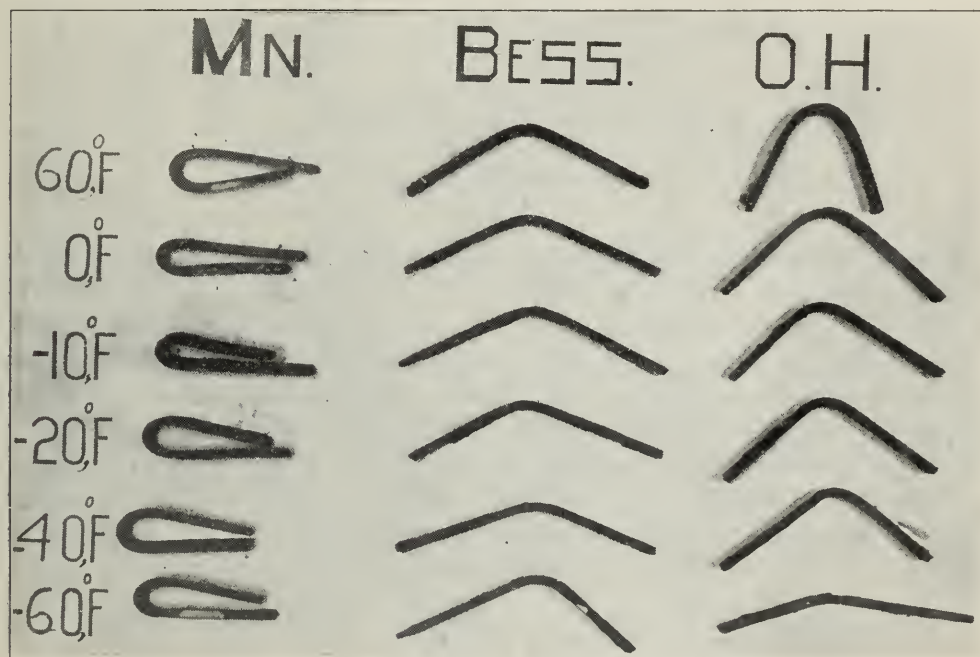


7

Illustration 7, shows the results of the first series of tests, to determine comparative physical properties at low temperatures on manganese steel, 1% soft carbon steel wire annealed and annealed

1% carbon tool steel. The four pieces at the left are manganese steel. Three bent double without signs of failure. The fourth, bent at -310 deg. F. failed at the angle shown. However, this piece showed by its fracture that it had been slightly burned on the skin in the open fire when heated for forging. The three other tests show that the manganese steel is tough at the temperature of liquid air, namely, -190 deg. C., or -310 F. The annealed wire which appears in the second column of bent specimens remained tough at -150 deg. F., but broke at 180° deflection and at -240 deg. F. At -310 deg. F. this soft wire became very brittle and when bent in the V-block went into many small pieces, so that the largest piece that could be found is the piece shown at the bottom and opposite -310 F.

In the third column, are shown tests on the 1% carbon steel. This deflected about 65° at ordinary temperatures, but at -150 deg. F. it was about as brittle as glass. At -240 and -310 deg. F. it broke into such small pieces that nothing worth showing could be found on the floor.



8

Illustration 8, is a series of bending tests on six specimens, each cut from the heads of rails and forged. The bars in the left hand column are manganese steel and all bent 180° without fracture. In the second column the bars are Bessemer steel and the third is of Open Hearth steel. All the bars in the second and third columns are broken through and the two pieces brought together in the position of failure, showing the greatest angle of deflection that could be obtained at the several different temperatures ranging be-

tween $+ 60$ deg. F. and $- 60$ deg. F. These tests seem to me sufficient to show that Bessemer and Open Hearth rail steels are less tough at temperatures below zero Fahrenheit than at ordinary temperatures.

Scleroscope Determination of. Hardness of Rolled Mn. Steel Rail.

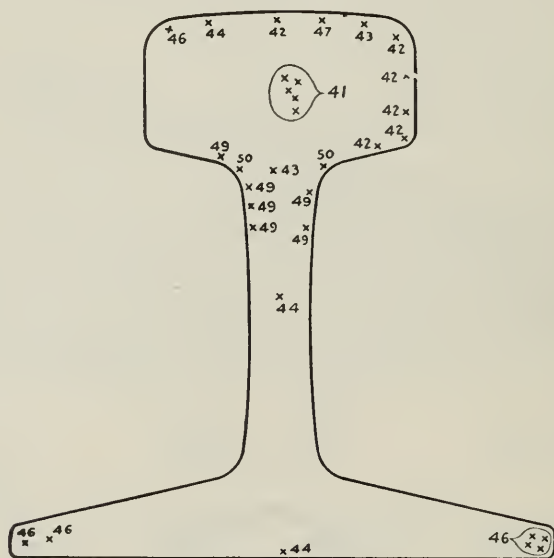


Fig. 9

Fig 9, shows the hardness of manganese steel rails as found by the Scleroscope. The rail was cut off by means of a friction disk, which, of course, heats the metal in the neighborhood of the cut to a slight depth. Then $1/16$ inch was ground off from the end of the rail on a wet stone and the test made. The softest points are at the center of the rail. The hardest points are in the neighborhood of the fillet under the head where the work was greatest.

It is interesting to note that the hardness found on the entire surface of the section, as made by the friction disk was the same as the hardness at the center of the ground off end, namely 41.

APPENDIX

RESULTS OF DROP TESTS.

Digest of report of R. W. Hunt & Co. on testing twelve specimens of Manganese Steel Rail, made by the Manganese Steel Rail Company, each specimen being from a different heat of steel.

"The tests were conducted on a standard rail "drop testing" machine. The weight of the tup or drop was 2000 lbs., the difference between the supports in the clear was 3 ft., the weight of the anvil and anvil blocks was over 20,000 lbs.

"Tests A, B, C, D, E and F constitute the regular tests which rails of 85 lbs. section are subjected. The rail is given only the one blow which it is supposed to withstand without fracture.

No. of blows.	Ht. of drop in ft.	Specimen.	Deflection in inches.
I	17	A	1 11/16
I	19	B	2 5/16
I	19	C	2 5/8
I	19	D	2 7/16
I	19	E	2 5/8
I	19	F	2 13/16

In tests G, H and I, the rail pieces were subjected to successive blows of increasing height. The test pieces were removed after each blow and the deflection or permanent set measured. The tests were continued until the rail was either so distorted that it was impossible to set it on the supports of the drop testing machine or until the deflection was so great that it was impractical to test further.

No. of blows.	Height of drop in ft.	Specimen.	Deflection in inches.	
1	4	G	5/8	
2	6	G	1 7/16	
3	8	G	2 1/2	
4	10	G	3 5/8	
5	12	G	5 1/4	Too badly distorted to test further.
1	4	H	5/8	
2	6	H	1 7/16	
3	8	H	2 1/2	
4	10	H	3 3/4	
5	12	H	5 1/4	
6	14	H	6 3/4	Too great a deflection to test further.
1	1	I	1/8	
2	2	I	3/8	
3	3	I	3/4	
4	4	I	1 3/16	
5	5	I	1 13/16	
6	6	I	2 1/2	
7	7	I	3 5/16	
8	8	I	4 5/16	
9	9	I	5 1/2	Too great a side sweep to test further.

Rails J, K and L were subjected to the first blow with the rail head up, and and to the second blow with the rail reversed or base up, etc., as indicated in the tabulation given.

No. of blows.	Height of drop in ft.	Specimen.	Deflection in inches.	Head, base or side up.	
1	19	J	2 3/4	Head.	
2	19	J	0	Base.	Practically straight, flanges bent.
3	19	J	2 9/16	Head.	Some side sweep.
4	22	J	0	Base.	Practically straight.
5	24	J	2 9/16	Head.	Too much side sweep to test further.
1	24	K	3 5/16	Head.	
2	24	K	0	Base.	Not quite straight, large side sweep.
3	24	K	5	Side.	Too badly distorted to test further.
1	24	L	2 1/2	Head.	
2	24	L	0	Base.	Considerable side sweep.
3	24	L	6	Side.	
4	24	L		Side.	Slight sign of flange tearing.
5	24	L		Side.	Fracture of both flanges to web.
6	24	L		Side.	Complete fracture.

DISCUSSION.

President Allen: I want to express the appreciation of the Society for this extremely interesting paper from Mr. Potter. I am sure that most of us have learned something new in regard to this most interesting material. We are familiar with the various uses of steel; we know its persistent defects and the resulting accidents and costly operation of our railroads and other industries. We are all interested in the prospect of finding a solution of these difficulties and in getting material which will give us reliable service in engineering structure. Here is a material which gives indications of being extremely adaptable to a variety of uses, and I hope that the discussion this evening will bring out many points in regard to the uses to which manganese steel may be put, also how it will respond to the ordinary processes of manufacture, and what are its limitations when used in engineering work.

Mr. W. E. Symons, M.W.S.E.: This paper without doubt is a very interesting one and brings up for study and thought, we might say, almost an entirely new phase of the steel industry with respect to the use of this material, both in railway and other engineering work. The particular feature which is of the greatest interest to the membership of this society, is in connection with railway work, especially rails, switches and frogs. Not only the life of the rail, as measured from the standpoint of the tonnage moved in a given period is to be considered, but particularly the wear of the rail-head, or ball of the rail, from lateral thrusts of wheel flanges when rounding curves, also the ability of this new material to resist the flattening out process, or the flowing of the metal on the base of the rail due to heavy axle loads.

It is not many years ago that locomotives with over 40,000 pounds on each pair of drivers were considered very heavy engines. As larger engines were constructed to pull heavier trains and the axle weights were increased to 42,000, 45,000 and 48,000 pounds, motive power officers were cautioned about going too far in that direction, with the admonition that to exceed 50,000 pounds per axle was dangerous to track, in that the rails would not stand such excessive load; also that the unfavorable results observed from the use of engines of such weights prompted a limitation to be placed beyond which it was not considered safe to go without inviting injury to the rails.

Later on, however, the axle loads were increased from 50,000 to 52,000, 53,000 and even 54,000 and 55,000 pounds per axle has not been uncommon for some years past, while some passenger locomotives have recently been built with 63,000 pounds per axle which is over 31,000 pounds per wheel, the diameter of the wheels supporting these loads being 68 to 80 inches, and such engines are run from 60 to 75 miles per hour.

It would, therefore, be quite interesting if Mr. Potter would in

his closure, indicate what might reasonably be expected in the way of comparative results between manganese and Bessemer steel rails under the extreme load and speed limits now being supported by the superstructure.

There is another feature in connection with axle loads, that is, with respect to the different kinds of locomotives, steam and electric. I assume, although I may not be correct, that with the electric locomotive and possibly with the four cylinder balance compound locomotive, rails will stand a higher load limit than when carrying the ordinary locomotive of equal weight, in that there would be an absence of any disastrous effects from the hammer blow, or the counter-balance so common in the ordinary type of locomotive.

In addition to these features mentioned with respect to rail wear and axle load, I will ask if the author will not give some information in reference to the character of the material in one of the ingots, (I think it is the one marked Exhibit A-3) which has the appearance to me of having been poured or cooled under foundry conditions that resulted in the segregation of the metals of certain fusing temperatures. This action, I believe, is commonly referred to by foundrymen as liquation or separation of the metals. The appearance of the ingot, or the face of the fracture, was that some action of this kind took place in cooling, and it would be interesting to know just what was the cause of the difference between the ingot, or casting, referred to and the others which show an entirely different condition, or character of metals.

Mr. Potter: Answering the first question, I regret that thus far we have comparatively little data on long service tests of rails. It was largely for this reason that I declined to read a paper on manganese steel rails. The rails which have been in test for the longest time are on elevated structure and exposed to the action of many wheels in a day, but with those wheels bearing light loads. The engineer reports that it is entirely too early, the test having only continued for four months, to make a report on the wear value of these rails. The engineer says, however, that the loss from the crown of the rail is in thousandths of an inch, and probably not greater than five-thousandths of an inch and that in that time, Bessemer rails on the same curve, as shown by the average of several sets of rails on those curves, would average more than four-tenths of an inch. So that we have, at the outside, five-thousandths of an inch as compared with four-tenths of an inch as the comparative wear value of manganese steel and Bessemer rails. That is perhaps much too high a ratio to anticipate as to results of even light traffic. So far it is practically the comparison of something and nothing. No conclusion as to rate of wear can be drawn so far. Still, it can be stated that the wear will be as high as 30 to 1 in elevated and sub-way traffic where the wheel loads are light and the car construction good.

We have no rails which have been subjected to the action of heavy locomotives for a long period. Some manganese rails have been laid on steam roads and exposed to the heaviest coal loads and heaviest types of freight engines. On curves where the trains come down steep grades and strike those curves with the maximum speed for freight trains (in some instances 45 miles per hour), the ends of the rails show thus far no flattening. The sides of the heads and the tops of the rails show practically no wear. The best carbon steel rails laid at the same time have already lost from the side of the head near the upper fillet about $3/16$ inch, and from the top of the rail about $1/16$ inch. Still, it is much too early to make a comparison.

On intersection work we have had rails in long enough to out-wear some eight equal intersections made of Bessemer rails. In this connection two interesting facts were noted: First, the end of the manganese rail shows less flow, or peaning, in its long life than the Bessemer rail in its short life. The comparison was made in two years in the one case against two months in the other. The Bessemer rail flowed at the end about $3/8$ inch in two months. The manganese rail after two years had a flow of about $3/16$ inch at the end of the rail. On the side of the head in these intersections the manganese steel rail lost but very little. During two and one-half years half as much was lost from the top of the manganese steel rail as from the Bessemer rail.

Manganese does not segregate in freezing steel. Sample A-3 is not a manganese steel but a carbon steel high in manganese and the different structures noted by Mr. Symons in the different portions of the fracture are the result of different cooling conditions.

Mr. C. L. Strobel, M.W.S.E.: I will ask Mr. Potter if he will not give us some information as to cost? the cost of the manganese cast steel rail and the manganese rolled steel rail. Also what is to be done for the drilling of holes for splice bars, and whether steel of that kind can be machined or is it to be used without machining entirely?

Mr. Potter: Some few years ago, about the time of the Spanish war, manganese steel was manufactured at about the rate of 100 tons per month in this country. Now it is undoubtedly as much as 1,000 tons per month, cast, forged and rolled, all together. Of course, if manganese steel rails are to be a success, the tonnage will have to be several thousand tons per month of rolled rails. It is safe to say that the cost of rolled manganese steel will be much less than the cost of manganese steel castings. Manganese steel castings have cost the manufacturer in the neighborhood of 6c. and sometimes as low as $4\frac{1}{2}$ c. per pound. The prices have been arbitrary. The prices on rolled steel rails are at present arbitrary. The price is now \$180.00 per ton, but the future will undoubtedly bring that price down where it belongs, and so that the rails can be

used even on straight main line track. The price will be determined entirely by the tonnage used.

With regard to the machining of the metal, considerable progress has been made. In rails the holes for fishing can be punched cold and the injury to the rail web is very slight. When the web of the rail is punched every 6 inches and the rail then bent sharply in a press, you can hear the metal crack with a sharp snap in the neighborhood of the hole when the deflection is great enough. This shows that the steel is not damaged by punching. The fish plate holes can also be drilled but the cost is high. In 1901 an inch deep in one hour was considered good drilling. The best recent drilling is an inch in about ten minutes. The steel can also be planed, and very heavy cuttings can be taken off by heating the surface to about 400 degrees Cent. Machining of any consequence will have to be done with the best and strongest tool steels that can be produced.

Mr. E. H. Lynde: In your experiments, what are the comparative results, as far as you have made observations, of "piping" in connection with Manganese, Open Hearth and Bessemer steel?

Mr. Potter: The Bessemer ingot, which is poured and left without a cover, usually shows a cavity in the top with a light shell about it. As the car on which the ingot rests is moved, the steel will generally settle down with the formation of a second pocket, and there is some sponginess below that pocket. As you are undoubtedly aware, considerable cropping is necessary. Some open hearth steel plants are putting covers over the surface of the metal after pouring the mould very full. This hot cover put on the top of the ingot mould helps to reduce the action of the piping, although the sponginess is greater in open hearth than in Bessemer steel.

If you have a red hot brick cover the metal will settle down without much piping, and the total sponginess and piping together will be limited. Manganese steel poured in an open mould, without the brick cover, pipes very deep. It is not a pipe caused by gases in the metal. It is due almost entirely to shrinkage. The melting point is very low and the steel is apt to be very hot when poured. The metal in the center of the ingot may be liquid for a long time. Presently there is a long tube filled with liquid steel. As the metal in this tube settles the result will be a deep pipe if no remedy is applied. I have run a rod of manganese steel down into an ingot of manganese steel and felt the shell of steel frozen over the bottom plate at the end of thirty minutes. That was only a 12 in. square ingot, by the way. As you see, it is an entirely different problem from the casting of carbon steel ingots. I have never seen anything that looked like a blow hole of any size in a manganese steel ingot. The percentage of elements present, which are more energetic than iron to absorb oxygen, is high. You have, say, 12.5% as compared with about 1.40% in carbon rail steel. The absence of blow holes in manganese steel is undoubtedly due to this high percentage of reducing agents. To avoid pipes in manganese steel ingots a special

method of manufacture is necessary. This can be done by refilling.

President Allen: Let me ask if manganese steel has been used in die forged eye bars and in plates or shapes for structural work?

Mr. Potter: Not to my knowledge, but it will probably find its way into very high class structural work.

Mr. Lynde: Have you made any vibration tests as compared with Open Hearth or Bessemer steel?

Mr. Potter: I regret to say that no alternate stress tests have been made, but a near approach to such a test is the commonly used test of bending a bar back and forth. Manganese steel stands such a bending test very well.

Mr. Charles K. Mohler, M.W.S.E.: I would ask if manganese steel has been extensively tried or used for gears or other forms of construction to take the place of cast steel or cast iron? We had a paper recently on "Steel Castings" and the point was brought out that considerable trouble had been experienced in the matter of getting satisfactory castings for gears, and I would like to know if you have had any trouble in getting manganese steel castings of that type? Does the excessive shrinkage in large or complicated shapes give the same relative difficulty that is experienced with the ordinary cast steel?

Mr. Potter: There are a great many cast manganese steel gears now in use and more are being used all the time. They have been used in rolling mills and in various classes of work where the drive is heavy; bevel gears, for example, from 6 to 8 inches in diameter. There are many such gears in use and they are giving good results.

Mr. Symons: Has there been any use of manganese steel so far, in a car wheel, a steel tire for a car wheel, or locomotive driving wheel? The wheels in present use wear quite fast, particularly the flanges which are affected much more than the tread of the wheel. Cast iron or chilled wheels, in common use under freight equipment, are, as a rule, sold under a mileage guarantee of about 60,000 miles or 5 year's service. In some sections of the country the best results are about 30,000 miles to the life of a wheel, or only about 50% of the guarantee, and the failures are largely due to sharp flanges, the wear being greatest, of course, when rounding curves.

In locomotive operation the question of removing driving wheel tires (particularly on mountain roads where they have become worn sharp by rounding curves), is a serious one, from the standpoint of expense incurred in doing the work, the loss from the use of the engine while out of service, and the possibility of accident should the work be delayed beyond a reasonable period. How to overcome some of these adverse affects or to minimize this difficulty is quite an important question. It is now common practice, in some parts of the mountainous railway districts, to use a lubricator on the flanges of locomotive driving wheels; in fact there are several patent lubricating devices now in use for the sole purpose of extending the

life of the tire, or the flange of the tire, between regular periods of removal or shopping the engine for returning the tires.

The lubrication of the flanges thus described also tends to increase the life of the ball of the rail, which, in the absence of lubrication is ground away by the lateral thrust of the wheel flanges grinding against the outer rail when rounding curves. It occurred to me that possibly the use of manganese steel for tires on locomotives or for full size wheels under cars would doubtless increase their wearing qualities over that of the present material used, and it would be interesting to know if such use has been either tried or contemplated.

Mr. Potter: Cast manganese steel wheels have been tried and found to flatten. The elastic limit of the cast steel is usually about 43,000 pounds while the rolled steel may have an elastic limit above 70,000 pounds. Forged manganese steel on account of the higher elastic limit might make a wheel which would not flatten and which would be very strong and durable.

Mr. A. C. Smith, M.W.S.E.: What is the reason that the outer skin of manganese steel castings is softer and wears quicker than the balance of the metal?

Mr. Potter: After annealing, the steel is undoubtedly decarbonized somewhat on the skin and to quite a depth. The combustion carbon determinations compared with color carbon tests show less alteration of the steel than on the outside of a manganese steel casting. On this account the skin can usually be chipped quite easily. When you get in a little way it does not chip quite so easily. After the surface of track castings has been worn off by the wheels the balance of the casting wears better. If the casting has been burned ever so little in the reheating and quenching process the cast steel wears very fast at first.

Mr. W. S. Weston: I would ask if the cast steel can be reheated and quenched any number of times?

Mr. Potter: I do not think there is any objection to several reheats, if it is done right. I have tried it and there was no evidence of damage. If castings are heated a little too hot the carbides are broken up unnecessarily and the steel will then be too soft, but proper reheating does not soften the steel very much.

Mr. H. S. Bowen, M.W.S.E.: I would ask Mr. Potter if he has had any experience in welding manganese steel to other grades of steel, under the hammer, and if it would be possible to get a weld or cementation of manganese steel heated by pouring hot steel on to a manganese steel plate? In other words, would it be possible to get the wearing qualities of manganese steel on the outside surface of a large casting or a large forging, without having to use manganese steel throughout the entire body?

Mr. Potter: That is a question which takes us back to this ingot nearest me. Specimens A-2 and A-3 are metals which are about

the same as you would get if you could get the manganese steel and the carbon steel to flow or run together on the joint of such composite work as you have mentioned. The result is an utterly worthless metal. If you could get a flow between manganese steel plate and carbon steel poured upon it so there would be a gradation in the composition from one to the other, you would have an intermediate metal that would not be safe as a joint to hold the two parts together. A piece of manganese steel and a bar of low carbon steel were recently forged together. They appeared to be welded and were drawn out under the hammer. The forging and welding was done at a low heat; 950 to 1,000 deg. Cent.; the blows were heavy. Bent *toward* the carbon steel, the bar withstood a bend of 90° but bent the other way it opened on the joint from end to end. Manganese steel can be welded to manganese steel if a proper flux is used or if the formation of oxides is avoided in the heating. You can pour manganese steel on manganese steel and get a very good weld.

A Visitor: Referring to the non-magnetic qualities of manganese steel, there is an electrical field for this especially in high speed machines. The only steel I know of which is now used in this way is a very high nickel steel running about 50% nickel. I would like to know whether there is any prospect, in the near future, of manganese steel becoming a competitor of this other material. Of course it means machining. The parts required would be perhaps 40 in. in diameter, the thickness might be 2 in. and the length from 15 to 20 ins. Take for example a ring 40 in. in diameter by 50 in. in length, 0.75 in. thick; is there any prospect that manganese steel will be used for that?

Mr. Potter: Yes. If you would be satisfied with a smooth rolled plate welded at its ends to form a ring, I think you could get a very good ring. Certainly manganese steel is cheaper than 50% nickel steel. You could machine that ring with an emery wheel and it would still be cheaper than 50% nickel steel.

Mr. Lynde: Has there been observed any difference between manganese steel and ordinary Bessemer steel, in regard to rusting?

Mr. Potter: There are tests going on to determine that but I think H. M. Howe could answer that question. There may be something in the proceedings of some other society which would give that information. I am told that Mr. Howe put bars of manganese steel in a lake near the plant where he made his experiments and left them there for several years. As the tests were never published I am inclined to think that the results were not favorable. As we may expect a very long life from manganese rails we can afford to coat them with paint or oil if that is found necessary.

A Visitor: How do you manage to get drillings for samples for analysis? Also, what can you tell us about the comparative wearing property of cast manganese steel rails as compared with those that are rolled?

Mr. Potter: Answering the last question first. The time is too short yet to give proper comparison as to wear of the rolled section as against the cast manganese steel rail, but so far as tests have gone no difference appears. In regard to the drilling of samples for chemical analysis, I tried for a long time to find a tool steel that would do the work. Mr. Clarage, of the Columbia Tool Steel Co., saw my difficulty and showed me a little case of specimens of steels which had been tempered right and wrong, and soon convinced me that I did not know anything about the tempering of tool steels. He gave me some definite rules and I found that if I did not heat the steel too hot, that if I quenched it at the right heat and then did not draw the temper at all, it would drill the manganese steel. The drill must be immersed in water just far enough, and of course, must be properly formed so that it will be strong when the temper is not drawn.

Mr. E. T. Clarage: Manganese is a very peculiar metal and under different conditions shows very contrary results. One of the peculiar features about chemistry is that when you mix two substances belonging to widely separated groups, you can usually calculate what the result will be, but when you mix elements which are very closely related, in fact, belong to the same family, the result is sometimes much as it is with human nature, they may not get along very well together.

Steel makers have progressed possibly as much as any other line of workers. The old way to build a house out in the country was to invite all your friends and have a raising bee. Some one would say, "Jim, where do you want this partition?" and Jim would say, "You better put it about there." Nowadays, the way we build houses is to construct them first on paper and everything is carefully planned before the work is commenced. It might surprise anyone not actually in the manufacture of steel, to know how much steel making is first done on paper under our present methods. Everything is carefully calculated beforehand and generally we know somewhere near what the result will be, but not always.

In practical demonstrations, we sometimes find that some of the things which appear very simple, turn out to be simply *awful* before you get through with them.

Mr. Potter has shown you the non-magnetic properties of a high manganese steel. Yet so contrary is this metal that some manganese is absolutely necessary to produce the best cheap commercial magnet steel.

I dare say there are a number of gentlemen here this evening who are interested in electrical engineering and who probably know that the best commercial magnet steel is 0.55 to 0.60% carbon and 0.85 to 0.90% manganese. Steel containing manganese in that proportion makes a very strong, permanent magnet, but one of the inexplicable things in connection with metallurgy is that with man-

ganese carried to excess, you get a positively non-magnetic steel, as has been shown you.

Mr. Potter conducted a number of his experiments near our mill at one time, and I want to say to you that the information of which he is now in possession did not come easy. I have seen Mr. Potter go into the works full of life and energy, and I have seen him come out a couple of days after, with deep lines on his face, with his eyes blood-shot and his clothes burned full of holes, after spending two or three days and nights constantly at the furnace without any sleep. These things do not come easy. They only come through exceedingly hard work.

RELATION OF LOAD FACTOR TO POWER COSTS

MESSRS. E. W. LLOYD, A.I.E.E., C. A. S. HOWLETT, M.W.S.E.
AND J. M. S. WARING, A.I.E.E. AND M.W.S.E.

*Presented at a joint meeting of the W. S. E. and A. I. E. E.,
March 2, 1909.*

Mr. W. L. Abbott, M.W.S.E., Chairman, Chicago Branch A.I.E.E.: It is certainly very gratifying to see the attendance this evening at this our first "doubleheader" meeting. The committee for the Chicago Branch, A. I. E. E., had secured a paper relating to the subject to be discussed this evening; it also occurred that the Electrical Section of the W. S. E. had a paper on the same subject; as these papers were to be presented about the same time, it was thought desirable to hold a joint meeting for the presentation of the papers and a general discussion of this important subject. It is by the courtesy of the Chairman of the Electrical Section W. S. E. that the Chairman of the Chicago Branch A. I. E. E. presides this evening.

As there is no routine business of either body to come before this meeting, we will proceed at once with the papers for the evening. These are on the "Relation of Load Factor to Power Costs," and will be presented by Mr. Lloyd, of the Commonwealth Edison Co., Mr. Howlett, of the Western Electric Co., and Mr. Waring, of the Electric Storage Battery Co.

THE LOAD FACTOR.

Mr. E. W. Lloyd: A great deal has been written regarding the bearing of the load factor in a given plant on the cost of producing and selling electricity, and it now seems to be generally accepted that this is the logical basis from which to consider the matter.

Admitting this to be the proper method of determining these factors, it becomes necessary to have practical information as to the load factors of different industries before we can arrive at the probable cost of such power. It is not many years since most manufacturers thought that the actual connected motor and lamp load was the maximum of his plant, but we to-day know that this is not true in the average case, and that the true maximum is in many instances considerably less than the connected load.

In determining the load factor of a plant it becomes necessary to have a maximum measuring instrument. For use on direct current circuits such instruments have been developed; the instrument being of a type both efficient and cheap, but for measuring the maximum on 3-phase alternating current circuits we have not been so fortunate. So far as I know there is not available to-day a cheap and efficient instrument for this service. In order then to carry on the practical business of selling energy at differential rates it is

necessary, where the system of generating is alternating 3-phase, to establish a schedule of percentages, or to make tests from time to time of the maximum demand of any installation. We have adopted a schedule of percentages, compiled from actual readings taken from direct current installations. This has been used for two years, and we have found these percentages to be very close in a great majority of cases. This schedule is as follows:

Installations under 10 H. P. where only one motor is used....	85%
Installations under 10 H. P. where more than one motor is used.	75%
Installations from 10 H. P. to 50 H. P., both inclusive, irrespective of the number of motors.....	65%
Installations over 50 H. P., irrespective of the number of motors used.....	55%

While this table may appear low, to some, for installations above 50 H. P., we find from actual data that it is often high. Of course, when you take into consideration the demands of motors driving blowers and ice machines, or other apparatus in this class, the percentages enumerated are probably low, but generally speaking the average manufacturing plant does not consist entirely of machinery of that character. In order to protect the power company against demands greatly exceeding these percentages, a clause can be incorporated in agreements providing for the test of the maximum at any time. It might be interesting to know that out of 3,900 consumers of power, having installations aggregating 35,000 H. P., the average maximum was 53.5% of the connected motor load, and that this was subdivided as follows:

	Max.
1 to 5-H. P.—2,900 customers.....	75.4%
6 to 10-H. P.— 456 customers.....	64.5%
11 to 20-H. P.— 237 customers.....	64.7%
Over 20-H. P.— 307 customers.....	42.9%

Tests taken by curve drawing instruments, and by the reading of watt meters during five minute intervals indicate wide variations in the load conditions on almost all manufacturing plants. Maximum load conditions in factories in Chicago seem to be between 4:30 and 5:00 o'clock in the evening, regardless of the time of the year. Further, the maximum load condition in these plants does not always come at the time of the peak conditions of the central station. Of course, there is a point of high maximum in these plants at the time of the central station peak, but the highest maximum of the plant usually comes before the time of the central station peak. This falling off of the factory load before the time of the central station peak is partially the reason that a central station company is enabled to carry on much more business than it would seem they were able to.

There seems to me some difference of opinion as to the meaning of the word "load factor." Generally speaking, it is known as the

ratio of the average load 24 hours a day, 365 days per year, to the maximum load indicated at any time during the year.

There is considerable difference in the load factor of different industries. For instance, the load factor for elevator service is not to exceed 10%, while that of refrigeration business is probably in the neighborhood of 50%. The average load factor of street railway systems is probably 35%, so that you see consumers of electricity having load factors exceeding 50%, or in other words the use of the maximum twelve hours each day, are very rare. It, therefore, seems reasonable to suppose that the load factors of central stations will not be much greater than this for some years to come. The load factors served, is such as to have more than one-half hour periods factor of any central station cannot exceed this figure until nearly all of the business of a community has been obtained, and where the diversity factor, due to the large number of different kinds of customers of maximum use.

Mr. Abbott: In arranging for these papers, it was recognized that it was wise to have a representative of the manufacturers; for that purpose, Mr. C. A. S. Howlett, of the Western Electric Co., was asked to prepare a paper, and has done so, but through illness, is not able to be present. He, however, has handed his manuscript to Mr. Grant (also of the Western Electric Co.), whom I will ask to present it.

LOAD FACTOR AND RATES.

Mr. C. A. S. Howlett, M.W.S.E.: The manufacturer's position in this question of load factor and rates is of supreme importance, especially as it applies to power rates.

The cycle of operation may be considered taking place as follows: The central station develops and adopts equitable power rates that encourage the use of motors; the manufacturers design and construct efficient and reliable motors and see that the customer makes a proper selection and installation; satisfied customers mean more business both for the central station and the manufacturer.

The two vital elements that the manufacturer must consider is an efficient installation and, if alternating current, one with as high an average power factor as possible.

The typical central station is not unlike the water power plant; it has surplus capacity for a greater part of the time, and all the systems of rates aim to equalize this condition.

The development of a successful rate involves the analysis of the cost of generating competing power, locally, by such different methods as steam, natural gas, producer gas, illuminating gas and oil and a careful study of the load factor obtaining in each plant.

The importance of this analysis is apparent when the question of having the rates stated in the franchise, under which the company operates, is considered. No opportunity would be given to increase the rates even if it was found that the operating company was sell-

ing current at or below cost. The rates when settled usually govern all contracts throughout the life of the franchise.

The effect of load factor on the cost of power is readily understood where steam plants are concerned and its relation to rates for electric energy will be treated fully in the other papers presented this evening.

All rates must be arranged in such a way that they make peaks a prohibitive element. All central stations want to sell all of their power all the time and only constant vigilance will bring about this condition. For this reason it has become the practice with some to contract for a block of "firm" power and placing a penalty on the peak power.

Some rates are based on the monthly load factor. The total number of kilowatt hours for the month divided by the kilowatt of this average peak, times the number of hours, represents the monthly load factor.

It has been brought out by one advocate to change "load factor" to "loading factor" when applied to an industrial plant having violent swings of power, i.e., station loading factor equals average station load.

Total rated capacity, applied to an individual generating unit, is equivalent to the "per cent full load rating."

In determining the proper size motors to install in an industrial plant it seems to be the practice to take a portable motor as large as the largest that will be liable to be needed. The horse-power input is used as the basis and sometimes is multiplied by two for safe measure. The difference in efficiency of the testing motor running at fractional load is also in favor of having the motor too large.

In the case of a direct current plant these large resultant motors operating at fractional loads tend toward a dissatisfied power user, and if the plant is using alternating current, such a condition tends toward a low power factor.

For these reasons co-operation between the central station solicitor and the manufacturer's representative is earnestly recommended. Many economies can be brought about in a careful study of each application that will secure

1. A satisfied customer.
2. The central station a contented power taker.
3. The customer a correct and efficient power application.

Mr. Abbott: The third paper will be presented by Mr. J. M. S. Waring of the Electric Storage Battery Company.

Mr. J. M. S. Waring, M.W.S.E.: The topic for discussion this evening is the "Relation of Load Factor to Power Costs," and I have so interpreted this title as to include in the power costs, the fixed charges incident to the generating, transmission apparatus, etc., as well as the operating expenses, for there is a relation between the load factor and these fixed charges as well as between the load factor and the actual operating cost.

The fact that these relations exist (and that other things being equal, the higher the load factor the less the fixed charges and operating expenses for any given energy output), is so well known that an attempt to prove these facts would result in a demonstration of a self evident proposition, and I will, therefore, begin with the assumption that the fact is admitted, and will devote the major part of this paper to the description of a comparatively novel application of storage batteries where the ultimate benefit is an improvement in the load factor.

As a matter of fact, the installation of all storage batteries for railway and central station service has been made with a view of improving the load factor of the entire system or of some part of the system.

Most of these varied applications are well known to-day, and the time is too limited to make more than a passing reference to them. There is an application, however, that until recently has received comparatively little attention, but whose field is constantly enlarging, and will, I believe, result in more battery installations for railway, lighting and power service than any other single application. In order to obtain a comprehensive understanding of this application it will be necessary to lead up to it by a brief and necessarily academic discussion of power rates. This, I feel, will be justified in view of the facts that the value of the battery installation is here dependent on the nature of the rate, and that the result in this case, as in all the others cited, is the betterment of the load factor.

It is needless to say that for a power company to be on a paying basis, its total revenue must be more than sufficient to cover all fixed charges and operating expenses. The total expenses of a power company may be divided as follows:

(A) Fixed charges on equipment, including power house apparatus, transformers, transmission lines, etc., namely, interest depreciation, taxes, insurance, etc.

(B) Operating expenses made up of such items as fuel and feed water if it is a steam plant; oil, waste, incidentals, repairs and labor, including power house force, line men, etc.

(C) Organization expenses, including salaries of officials, clerks, solicitors, etc., office rents and such expenses.

If each customer of a power company is paying annually an amount sufficient to cover the fixed charges, operating and organization expenses, incident to his demand only, plus a reasonable profit to the power company, his rate is a just one, and every well organized power company knows that an unfair discrimination in rates must finally be disastrous. Power companies are, therefore, realizing more and more, the necessity of adopting a form of rate which will do justice to *all* of their customers as well as to themselves, and the tendency to-day is the adoption of a form of rate which will pro-rate the total expenses of the operating company as equitably as possible among its customers. In order to accomplish this;

April, 1909

First, all fixed charges and fixed expenses, namely, those that are constant and irrespective of the energy output of the plant should be divided among the customers in proportion to their maximum demand for power; then each customer pays the fixed charges and fixed expenses on the apparatus set aside for his use.

Second, all variable expenses, namely, those varying with the energy output of the plant should be divided among the customers in proportion to the energy they consume in a fixed time.

Of the various expenses under the headings, "A," "B" and "C," referred to above, the only variables in the case of a hydro-electric plant are the repairs, oil, waste, incidentals, and probably only a small part of the power house force, all the other expenses being practically fixed and independent of the load factor. In the case of a steam plant, however, the variables would include oil, waste, incidentals, fuel, feed water, repairs and a larger percentage of the power house force than would occur in the hydro-electric plant. Therefore, in general, the operating expenses, that is the variable charges are a greater percentage of the total operating cost in the hydro-electric than in the steam plants. Now the total fixed charges of the plant divided by its kilowatt capacity will give the amount per kilowatt which each customer should be charged for each kilowatt of his maximum demand. By doing this, the total fixed charges are properly pro-rated among the customers in the manner outlined above. The total operating expense of the plant for a fixed period of time, divided by the kilowatt hours output for that period will give the cost per kilowatt hour of the actual operating expenses, exclusive of the fixed charges, and this amount plus the company's legitimate profit would be the kilowatt hour rate that the customers should pay for their energy consumption. In other words, an equitable *basis* of power rates is the one where a customer is billed annually a fixed amount per kilowatt of his maximum peak, which we may call a primary charge, and is billed in addition to this a fixed amount per kilowatt hour, which we will call the energy charge. Power rates may apparently differ from this in form, but to be equitable they must be reducible to this basis, and a rate which is not reducible to it is not equitable. In order that this form of rate, or its equivalent, may be put in force it is necessary that the consumer's load factor be known in each case. His average load may of course be determined by an integrating watt meter. His maximum load, however, must be determined in order to establish the load factor. Usually the most accurate way of determining this maximum is by means of a meter, such as the Wright Demand meter, or a recording instrument.

Notwithstanding the fact, that the number of equitable rates in force is constantly increasing, I could cite actual cases of rates in force today, varying from the equitable basis referred to above, to the other extreme of the flat rate of, a fixed amount per month

per lamp connected. It may be interesting to mention several of these cases with a view of analyzing them, and determining how nearly they approach the equitable basis.

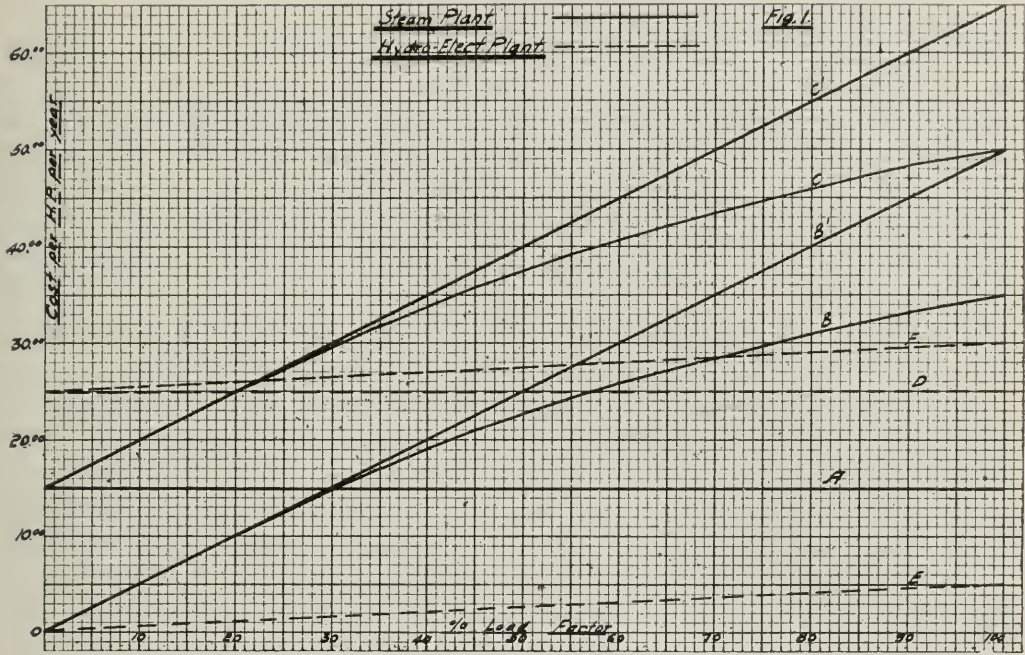


Fig. 1.

These analyses will, I believe, be made clearer by using the curves shown on Figs. 1 and 2 as illustrations. On each sheet the curves relating to steam operation are shown by the *solid* lines and those referring to hydro-electric plants by the *dotted* lines. In Fig. 1, the

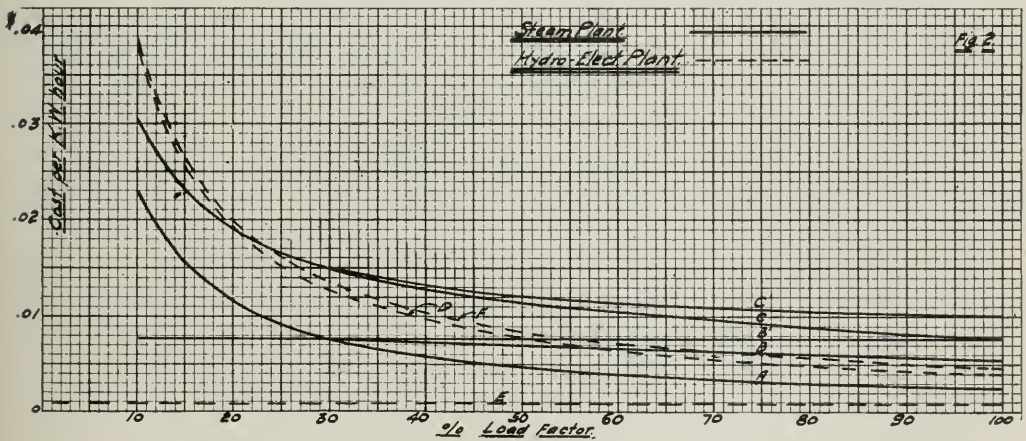


Fig. 2.

curves are plotted between per cent load factor and cost per H. P. per year, curve A representing the fixed charges of a steam plant; curve B, the variable expenses; curve C, being a summation of A and B; curve D, represents the fixed charges of an hydro-electric plant:

curve E, the variable expenses; curve F, being a summation of D and E. All of these curves may be reduced to curves as shown on Fig. 2, which is plotted between per cent load factor and cost per kw. hour, the cost per kw. hour, at any load factor, being equal to the cost per H. P. per year at the same load factor, divided by 8760 and multiplied by 0.746, multiplied by the load factor. Thus curve A, Fig. 2 is deduced from curve A, Fig. 1, the other curves in Fig. 2, being obtained in the same manner; the factor 8760 is the number of hours in a year. It should be understood that the values shown by these curves have been taken arbitrarily, and are not intended to represent any specific case, nor should any meaning be attached to the relative costs of steam and hydro-electric plants as shown by these curves.

1. *Water Power.* A primary charge of a fixed amount per kw. per year of the maximum kw. plus a fixed rate per kw. hour.

This coincides with the rate basis referred to. The maximum is taken as the average of the ten highest fifteen minute averages occurring during the year.

2. *Steam.* Same as 1, except that the maximum is determined as follows: The highest one hour average of every peak throughout the year is noted, and the highest average that can be obtained by averaging any six consecutive peaks is taken as the maximum.

3. *Steam.* Different rates per kw. hour specified for various load factors. Such a basis of rates could be fixed for the steam plant illustrated in the curves, by specifying the costs per kw. hour shown on curve C, Fig. 2 for various load factors, plus a profit.

This form of rate could be reduced to the general form by reducing curve C, Fig. 2, to curve C, Fig. 1, and separating this into curve A, Fig. 1 and B, Fig. 2.

4. *Water Power.* A fixed rate per H. P. per year times the maximum 1 hour peak. Such a rate is reasonably equitable for a water power plant. It would be quite so if curve F, Fig. 1, were horizontal; that is, if all expenses were fixed.

5. *Water Power.* A reservation charge of a fixed rate per H. P. of motors connected per month, plus a fixed rate for power per kw. hour.

This offers no inducement to the purchaser to improve his load factor, as would be the case were the reservation charges based on the maximum load instead of the rated capacity of motors installed. It is not fair to those customers who operate a number of motors each of which may at times operate up to its rating, but where the simultaneous operation of all of the motors at their rated capacities would never occur.

6. *A Fixed Rate Per Kw. Hour.* This rate is not a just one as no consideration whatever is given to the customer's load factor.

7. *Steam.* \$0.15 per kw. hour for the first 30 hours of the maximum demand, plus \$0.10 per kw. hour for all in excess of the

first 30 hours use per month of the maximum demand. This is equivalent to:

(1) The maximum kw. x 30 hours at 15c. per kw. hour, plus

(2) The total kw. hours minus (The maximum kw. x 30) at 10c. per kw. hour.

The Wright Demand meter records the maximum amperes (at 115 volts) during the month; (1) then becomes equal to the Max. Amp. x 0.115 x 30 x 0.15 = Max. kw. x 4.5, and the customer's bill is, therefore, 4.5 x Max. kw. plus 0.10 x (total kw. hours—30 x Max. kw.) = 4.5 x Max. kw. plus 0.1 x total kw. hours—3 x Max. kw. = 1.5 x Max. kw. plus 0.1 x total kw. hours; or, in other words, he is billed at \$1.50 per month per kw. of the maximum peak plus a charge of 10c. per kw. hour, which is the same as the general form of rate referred to.

8. *Water Power.* A reservation charge of a fixed amount per kw. per month times the maximum kw. plus a charge for power made up of a fixed amount times load factor times maximum kw.

If such a rate were adopted for the water power plant illustrated by the curves, the reservation charge should be approximately \$2.79

\$25.00 per H. P. per year

per kw. per month (= $\frac{\text{the figure } \$25.00}{12 \times 0.746}$)

12 x 0.746

being taken from curve D, Fig. 1), and the monthly charge for power would be \$5.00 plus a profit times load factor times maximum kw. The figure \$5.00 is the variable expense per H. P. per year at 100 per cent. load factor as illustrated by curve E, Fig. 1. The company's revenue would have been the same if their monthly power charge had been made equal to \$0.00076 per kw. hour, plus a profit times the number of kw. hours output for the month, since the figure \$0.00076 is taken from curve E, Fig. 2, which gives the equivalent costs per kw. hour at various load factors of the costs per H. P. per year shown by curve E, Fig. 1.

Hence this rate is directly reducible to the general form of rate previously referred to. The maximum in this case is arrived at by taking the average of the maximum two minute peaks for all the days in the month.

It is evident from the above that the equitable basis of rates or its equivalent offers an inducement to the Purchaser of power to improve his load factor. The battery application that I have been leading up to is that of a storage battery installed by the purchaser of power to reduce his maximum demand, and consequently his annual primary charge. From his point of view, the battery proposition to be attractive must insure him a reduction in his annual power bills sufficient to pay the annual fixed charges and expenses incident to the battery, plus a fair return on the battery investment; or, in other words, the yearly fixed charges and operating expenses per kilowatt of the battery (meaning the total annual cost of the battery divided by the maximum number of kilowatts cut off the peak),

must be less than the fixed charges and fixed expenses per kilowatt per year of the power company.

From the point of view of the power company, the betterment of their load factor by the Purchaser's installation of storage batteries makes possible a greater energy output for a certain plant investment, and therefore, a greater revenue since a part of the charge for power is at a fixed rate per kw. hour.

It is evident that the value of the battery situation will depend; *First*, on the breadth and shape of the peak; *second*, on the power company's method of determining the peak; and *third*, on the power company's method of determining its fixed charges and fixed expenses per kw.

As illustrations of how these items affect the battery situation, the cost of a battery to eliminate a certain triangular peak might be prohibitive, while a smaller battery to cut off less of the peak might prove a paying investment, for, due to the shortened base line, the cost of battery *per kw.* of peak would be decreased as the size of battery is decreased.

The power company's method of determining the peak has a distinct bearing. For instance, if the peak load of a railway is assumed to be the maximum one hour average load in one case, and the maximum five minute average load in another, the same size of battery might meet both conditions, and therefore cost the same, but it could reduce the peak more in the latter than in the former case, thereby effecting a larger return on the investment.

The power company's method of determining its fixed charges per kw. is also pertinent to the battery situation. In the case of a steam plant these charges can often be based on the overload rating of the generating units, while with a hydro-electric plant they can figure on very little, if any, overload capacity as the generator would probably be installed with a continuous rating nearly equal to the water wheel capacity. If the charges are based on overload ratings, the reduction of a certain amount in the peak would result in less reduction in the consumer's bills than if based on continuous ratings.

In conclusion, I would say, that I have only attempted to point out in a necessarily brief way, a just basis or form of power rate, and the discussion of such kindred subjects as off-peak loads, wholesale rates to large users, etc., are hardly within the scope of this paper. Local conditions may arise, and do arise, in specific cases necessitating some departure from this general form, but the fact remains that the nearer rates in force approach this basis, the more equitable they become.

DISCUSSION.

Mr. Abbott: The question of the proper method of charging for current has been a mooted one from the time that electric current was first sold. The first method of charging a customer for current was to charge him so much per lamp, for his connected loads:

that obviously had its objections to the power company which was paying the coal bills. The next method was to charge a fixed amount per unit of current consumed; and this, while having the precedent of the gas companies, soon developed its objectionable features. Since then various schemes and plans have been devised for combining these two features of charging, first, for the connected load or maximum demand, and second, for the amount of current consumed. The proper combination of the two is the subject which is interesting to power companies and consumers of electric current particularly for power more and more, and is the subject for tonight. I will call upon Mr. John F. Gilchrist to start the discussion, as one who has been in touch with this question longer, and has given it more thought than any one else in the city.

Mr. John F. Gilchrist: The question of an equitable charge for the sale of electricity is naturally based on the cost of producing that electricity. Really, the charge should be based on the load factor, that is, giving a higher rate to low load factor business, and charging a lower rate to higher load factor business. But to make the theory absolute, that is, to work out the practice along the lines of theory, you should follow the load factor at each plant rather than the load factor of the individual customer. That, however, has been found a difficult and complicated thing to do. And most of the companies supplying electricity have started with the assumption that every one was using power at the time of the station peak and that the loads were, in a very large measure, coincident, and have established a schedule based on the individual load factor. It is obvious that if you have two customers on a station the peak of which station occurs at five o'clock in the evening, and one of these customers has his peak, or at least uses an amount of current representing a large percentage of his peak at 5:30 p. m., and the other has absolutely no peak at that hour, but has his peak at nine o'clock in the morning, that it would be hardly fair to apply the same individual schedule to both customers. And yet, in a large system, dealing with a very large number of customers, it is a very difficult question to decide, and you are likely to run against municipal regulations if you attempt to differentiate between these two classes of customers. So, as I say, the power companies have gone back to the proposition that the man whose peak comes at nine o'clock in the morning is the rare exception, and have lined his business up at the same rate which prevails with the customers who are using current at the time of the evening peak. Possibly, if it could be worked out, a combination of a two-rate system and a demand system would be the ideal kind of charge.

It is very interesting to study the effect of the growth of business on the load factor of the large station. As the station grows and you get on a great variety of businesses, you find many very interesting things. For instance, take a large residence section where, in the individual case, the load factor will be low, we will say, the

average use of the maximum consumption is possibly two and one half hours daily, in the average residence district in Chicago; then take the station, or the sub-station, whose factor in large districts of residences where, so far as can be told from the general habits of the race and from the outside appearances of their houses the conditions are the same, and the peak comes at about the same time, you will find that the business as shown by the station instruments is four or five hours a day use of the maximum, so that if you base your rate on the individual peak, and that is based on the actual cost of producing energy for that particular customer, you have a big leeway in the improved load factor which you get in the aggregate. Now, as you increase your business and take on power load you will find that there is a diversity factor or lack of coincidence between the power load with the evening lighting load in the business part of the city, and the peak of the residence load. The evening, lighting load in the down town section of Chicago, for instance, at the time of the year when the peak is really a serious question, is perhaps at 4:45 to 5 P. M., whereas the peak of a distinctive residence section is eight o'clock in the evening. Then, if you are doing a railway business you will find that there is a still further diversity, because it is obvious that you can't have operatives working in the shops and offices and going home at the same time, consequently there must be some difference there.

In the street railway business we find, in this climate, that the absolute peak of the load, the annual peak, is apt to come in the months of January or February, probably in the latter month. This is due to climatic conditions. The peak of the railways on account of electrically heated cars is dependent more on the temperature than it is on the conditions of light and darkness; and in our climate, therefore, the peak comes when the coldest weather comes, which is ordinarily in January or February, where as the lighting peak comes in most cities, always in this city, before the Christmas holidays.

Now if you get into the business of supplying electricity to the trunk lines, the steam roads, you will find that their annual peaks come at a different time of the year from the other two, for reasons different from either of the others, namely, the greater industrial activity and the handling of the crops which comes in the fall of the year. The peak of the freight handling roads coming into Chicago will probably be found to be in the month of October. So that carrying out your central station to the theoretical limit and getting all kinds of business on it, the diversity factor will be found to be very good. There is an interesting matter in relation to load factor to be found in the methods of measuring the load of a street railway system. I suppose that the load factor of most of our Chicago roads, our big surface roads, will be found based on a momentary peak, to be in the neighborhood of 30 per cent,—somewhere from 30 to 35 per cent. If you stretch out your peak to five minutes you will have a better load factor. If you stretch it out to an hour it changes again.

We have found this impracticable, as most of you know who are familiar with the contract between the Commonwealth Company and the Chicago City Railway Company, which is a matter of public knowledge; in that we take the average of six peaks. Two peaks are taken, one from the morning and one from the evening of three successive days, and we find that the advantage to the railroad of that method of measuring, instead of taking the actual peak, is a saving of something like fifteen per cent; that is to say, the peak obtained in that way is only about 85 per cent of the actual momentary peak.

All of these things are of great interest, and it is very interesting to watch the change in the development and study the effect of load factor on the cost of producing energy.

Mr. H. R. King, M.W.S.E.: We, as manufacturers, are more inclined to look at it from our end, than from the central station end. We realize that cheap station power will increase the use of motors for incidental purposes, and we also realize that the problem of applying the motor to present installations is one which can give to the central station considerable assistance in that it will increase the load factor of the consumer, and thereby reduce the cost of power. It was my hope that Mr. Howlett would have touched on that and given some data, which I think he could have given, in connection with the actual results which are obtained.

Much can be done in the study of the application of motors in that direction, and we have found that great harm is done in the installation of too large a motor. Mr. Howlett brought this point out in part, and if the solicitors of the suppliers of electric power could direct the consumer in the direction of purchasing a motor of a proper size both the central station and the manufacturer would be benefited.

Mr. Abbott: The Chairman of the Electrical Section of the Western Society should, of course, discuss this matter. He is engaged in the business, more or less, of installing lighting plants, some of which I fear with the intent that they shall compete with central stations. I should like to have him give some justification for that.

Mr. W. B. Jackson, M.W.S.E.: I had supposed that my burdens were transferred to the shoulders of the other joint Chairman, but he has apparently thrust them back upon me. However, we are all so deeply interested in this question of load factor, whether we are managing an office, are operating an electrical plant, or whether we are advising clients as to the best methods for making electric light and power plants profitable, that I think we should all be willing to add our quota to the present discussion. The question of load factor enters into almost every line of work as an important consideration.

One phase of the matter that has not already been touched upon is the greatly varying effect of a poor load factor upon different water power plants. For instance in a hydro-electric project where

the low flow of the stream can be stored so as to be available for any distribution of load throughout the 24 hours, all of the power of the stream is available regardless of the daily load factor; the presence of a poor load factor has the effect of requiring a relatively large capacity of machinery, but it does not mean any loss in the usefulness of the water. But if we consider a water power plant that has little or no water storage capacity, and in which the load factor is not good, a large portion of the usefulness of the water will be lost, for either the water must be running to waste at times of higher load or else all load above the minimum must be carried by steam auxiliary. It seems to me that this element is not always given due weight in considering the value of water powers. This same line of reasoning is applicable to water powers having water storage of sufficient capacity to permit of carrying water over for days or weeks at a time as compared with powers in which such storage capacity is not available.

The problems arising from load factor which confront the managers of electric plants are of the same general character as those confronted in almost every line of business. In all kinds of business we endeavor to keep the load factor as good as possible; we endeavor to so arrange the work that there is the least possible difference between the busiest times and the slackest times and only thereby can we obtain the most economical service from our plants and employees whatever may be the business. Every mite of load that we can cut off of the "peaks" and throw into the hollows means real net gain. It is thus seen that this question of load factor is basic, though no such general and logical study had been given to the problem until it was so fully recognized and studied in the electrical business.

The point, that has been dwelt upon this evening, namely, the advantage as regards load factor which accrues to an electric light and power company which furnishes electricity for every kind of service be it large or small from a system operated as a unit, is one well worthy of consideration. And our Chairman will find that fair minded consulting engineers will not advise a consumer of electric light and power to generate his own power if he can receive service from the central station that will fulfill his needs and at a reasonable cost. It must be remembered, however, that there are many isolated plants in existence, and under such conditions it is frequently difficult for a central station to offer sufficient inducements to make it appropriate for the owners to throw aside the apparatus they have installed. But I believe that nobody appreciates more clearly than the thinking consulting engineer of today, the disadvantages to the central station of having portions of the territory through which its mains extend occupied by small competing plants. And I believe that every fair minded consulting engineer will be very sure that a client can make a *real* gain from having an isolated plant before he will advise its installation.

Mr. P. Junkersfeld, M.W.S.E.: The subject has already been pretty well discussed, but there is one feature that I believe has not been touched upon. As has been said before, of course equitable rates are necessarily based on cost of producing and distributing power. The cost of producing and distributing power has also been said to consist primarily of two features, the fixed charge and the operating cost, and that is true. But a further analysis is possible. The fixed charge consists first of the fixed charge on the amount of equipment that is actually necessary to supply that business, with certain risks as to whether or not the service will be continuous. It may also include a fixed charge on a certain surplus capacity to insure reliability, and that is a feature that has been understood to some extent for some time, but has recently been again brought out more strongly and more clearly than ever before in a paper before the "American Institute" by Dr. Steinmetz, and this is a feature that should be considered.

In certain sections of large cities it is necessary to give a very much higher grade of service. Take the city of Chicago, for instance, where the down town district is the keystone, you might say, of the arch. The customers need and the company for its own interest as well as for the public good, must give a better class of service in the direction of reliability, and that is a feature that enters very materially into the fixed cost. Now the effect of load factor on the total cost depends somewhat upon the amount of investment, for instance, with a larger investment per unit of demand, of course the variation in load factor will have a greater effect upon the total cost of supplying such demand. And the investment for insurance of the service rendered or in other words all investment over that actually needed for equipment to supply the demand under favorable conditions, is a very vital feature in the actual cost of producing and distributing the energy.

Mr. Abbott: With an equitable rate, such as one of the speakers referred to, a power company will make a price for current for the long hour user very low, therefore, what the power company wants is long hour users, and what the consumer wants is a power company which will make a low price. There is a certain benevolent institution which undertakes to bring these two interests into harmony. A representative of that company is Mr. G. H. Atkin, Manager of the Electric Storage Battery Company.

Mr. G. H. Atkin: The point regarding low prices to long hour users, is I think, covered in a great measure by Mr. Waring's paper; the function of the battery in cutting off the peak that Mr. Jackson refers to and putting it down in the hollow, we are performing right along, and I think the most recent and instructive case is the one in connection with the contract that Mr. Jackson referred to between the C. E. Co. and the Chicago City Railway Co. under which they pay a primary charge of \$15 per kilowatt per annum, and then on top of that so much per kilowatt hour used. The battery that

we have installed for them in Plymouth Court, cuts off from that peak 2500 kilowatts, which at \$15 a year, shows a gross saving of \$37,500 a year. That is the largest and most recent case in point, and the same thing, of course, can be done in much smaller plants where the load is very high, or where the power is very inadequate and there the storage batteries can be used to great advantage.

Mr. Abbott: We are fortunate in having with us as a guest this evening, one who is naturally interested in this work, Mr. Babcock, electrical engineer for the Harriman System.

Mr. A. H. Babcock: This paper is of great interest to me because on one side of the country we are the manufacturer of power, and on the other side of the country, the buyer. In the far west a great deal of the power is transmitted from the mountains, as you know, down to the large centers. In that district the railroad companies buy from a few lights, in a country station, up to 2000 or 3000 kilowatts in other places, for shop work and for railway propulsion purposes. Between these two limits you recognize a wide range of possibilities in the way of making rates.

From the mountains in California streams run down to the valleys and water storage is seldom practicable for two reasons; *first*, the extreme cost of building reservoirs in the high altitudes where construction work is possible only for a very few months of the year; *second*, if we do build expensive dams, we can store from one season to another or from one part of the year to another, but owing to the fact that from twenty-four to forty-eight hours are required for the water to come through the ditches and flumes from the reservoirs, down to the generating plant, anything like a daily peak-load storage is usually out of the question. Consequently flat rates prevail, and where consumers are on flat rates they will leave lights burning all day because it is easier than to turn them out, and they use very low efficiency lamps because their pocket books are not affected. Such consumers will not consider the eastern two-rate method of charging.

On the other side of the Sierra Nevadas, in the Salt Lake District, for example, the conditions are much the same, except that there we have a freshet season which comes in May or June owing to the melting of the snows; and in October we have one low water period, and in January or February we have another low water season, due to freezing.

To take one case in point, a stream for which we have just ordered a piece of machinery, has a minimum flow of about 200 second feet. During the early part of the year it will run to 300 second feet; in the spring time, or early summer it will run to 1000 second feet. That water cannot be stored from season to season but peak-load storage is obligatory because irrigation rights demand constant flow. We are, therefore, obliged to put at the head works a small dam which will give us daily storage capacity; and then at the tail race another dam which also stores that same water so that we are

able to turn a constant flow into the stream for irrigating purposes.

Now occupying these two positions you can see it is rather difficult to steer a middle course. Arguments put up on one side of the mountains for a low rate in the buying of power are not good on the other side when it comes to making a low rate where we furnish power. We have attempted in these cases to get "light from the east;" and the remarks made this evening are extremely interesting.

After all, while we can talk and argue on these points in a general way, as in these papers tonight, there is no general method, as far as I have been able to find out, that can be applied to such varying conditions. It seems to me in this, as in any other engineering question, one must take the conditions as he finds them and figure out his own solution as best he may be able.

Mr. Abbott: I see another gentleman here who is engaged occasionally in the business of installing isolated plants, and I trust he has seen some light here this evening to show him that with proper equitable rates such practice is not justifiable from an engineering standpoint; Mr. Postel.

Mr. F. J. Postel: There is one thing that has impressed me this evening, and that is, that large companies are principally the ones interested in the two-rate proposition. The small companies do not seem to worry about getting a rate which will be fair, considering the load factor. It seems to me the reverse should be true for it is more important for the small companies to consider this matter of load factor than for the larger companies.

A large company will naturally have the better load factor because it is in the position of the large consumer, while the small company is like the small consumer, with a more variable load and is in greater need of a two-rate charging system.

Another point that occurs to me is that in water-power installations especially, the company is justified in making a special rate to consumers who will take current at a time of day when the power company can best afford to furnish it. As Mr. Jackson says, the water is running away, at an absolute loss, and the cost to the company would be practically no greater if they furnished this power than if they did not. Under those conditions it would seem to me the company should be permitted to grant a special, low rate to a consumer who uses the power at that time of the day when the company can best afford to furnish it. Those are the two things that stand out most plainly to me this evening.

Mr. Abbott: There is a great deal of significance to that remark that the small companies should be more interested in the load factor than the larger companies, for the reason that the larger companies, having a larger number of customers, naturally would have a greater diversity of load, and the load factor of any one customer would have less effect upon the business of the large company than upon that of the smaller companies. But I believe that, as the speaker

said, the smaller companies give comparatively little attention to that feature of the question.

We have here Mr. Lyman, of the General Electric, who always can speak well upon any electrical question.

Mr. James Lyman, M.W.S.E.: Eight or ten years ago nearly all the electric light companies, devoted most of their attention toward getting lighting business, and their load consisted largely of the peak load limited to a short space of time. The Commonwealth Edison Company and some of the other large lighting companies realized that there was a great opportunity to improve the efficiency of their business by a power load, and very energetically went after it, with the results that have been related here this evening. Here in Chicago, with the downtown power load of direct current motors, the outskirts power load of alternating current induction motors, and rotary converters for the railway power energy, taken by the elevated and surface roads, they are furnishing a heavy power load at an extremely high load factor. Following their example, a great many of the smaller electric light companies throughout the country are going after a day load in all sorts of power, in heating appliances and, to a certain extent, cooking appliances. A comparatively small company in Iowa after selling induction motors for electric drive to all the other manufacturing companies, finally persuaded the manufacturer of gas engines to give up his gas engines and put in electric motors to drive his shop! This company has a load factor of something over 60%.

With almost all electric light and power service, where a large amount of induction motor work and arc light service is given, both the power factor and load factor may be improved.

The General Electric Co. has recently sold a number of rotary condensers which are synchronous motors with over excited fields. These are either located at the end of a transmission line, or in the power house of the local central station to compensate for the lagging current given by such apparatus as induction motors and A. C. arc lights. I have in mind a recent instance of a large inductive motor load, running light most of the time, due to a very fluctuating power load, a 2000 kw. turbogenerator was operated as a synchronous motor, with a gas engine driven generator supplying an energy load of from 1500 to 2000 kw., with an apparent load of some 6000 kilovolt amperes.

We received today, a letter from an engineer of a power plant in the mountains of Mexico, who recently installed a 1000 kw. turbogenerator, and in speaking of the load conditions under which he was operating he stated that he was obliged to operate his turbine 24 hours a day. In the month of January the turbine had delivered 790,000 kilowatts,—giving a load factor of a little over unity, as he expressed it, and it was an average load of 1070 kw. The coal used tested about 10,000 B.t.u. per lb. equivalent to 3.4 lb. coal per kw. hour at the switchboard. He has just been making some experi-

ments with crude oil, which showed a kw. hour at the switchboard from 30,000 B.t.u. This is a remarkably good showing and is in a measure due to the high load factor. There is a great deal of fuel lost in the banking of fires and the fluctuation of the load. It is possible to have, on a large railway plant, a comparatively high load factor, perhaps for eighteen hours of the day, and then for four to six hours, the load may entirely fall off, the fuel goes on burning, and while the load factor is high the cost per kw. at the switchboard is not low. Therefore, where power can be sold in the shape of motors or of heating or for electrolytic work, for manufacturing or for any other purpose that will bring up the load factor toward unity, operating cost will be a minimum. Wherever the power factor is low, synchronous or rotary condensers can be used to bring the power factor up, and this also will reduce the cost per kw. hour and enable the power-house to operate at maximum capacity, thus reducing the fixed charges.

Mr. Abbott: It is generally known, or perhaps we had better say, hoped, that all the trunk lines centering in this city are contemplating substituting electric power for steam. We have with us this evening the Chief Engineer of one of those large systems which may possibly be among the first to so electrify. I will call upon Mr. W. B. Storey to see if he can add something to the discussion this evening.

Mr. W. B. Storey, M.W.S.E.: With a chairman such as you have, I don't see as there is any need of my saying anything to enlighten you, as he knows more about the electrification of steam roads than the rest of us do, and it is his advantage and your gain. I notice in the discussion several problems which you are running across which we people, engaged in the line of railroading run across. You are worried about the rate question,—This seems to be one of the things in which there is a difference depending on whether it is a user or a buyer that is considering it. The principle that you seem to be talking on appears to be to get all you can for your power. I would point out that there are many similar features in that, to the establishment of rates on railroads. With us it is a question of getting all we can for carrying freight. There is nothing I can say relative to the subject in hand tonight that will help in any way, so I will simply thank you for calling on me.

Mr. Abbott: The North Shore Electric Company is represented here this evening. I would like to call upon Mr. J. L. Hecht.

Mr. J. L. Hecht: The question of load factor we all know is very important, but Mr. Lyman's remarks lead to another thing which I think has not been discussed fully, and it might be called the "*station characteristic*." For instance, in stations of three or four thousand Kilowatts capacity, the number and size of generating units, as well as the number and size of boilers, will have a decided effect on generating costs as the output varies. As the output of a station increases, the generating cost would undoubtedly decrease until the point is

reached when it is necessary to start up an additional generating unit or to add more labor or start up additional boilers. At that point the generating cost would undoubtedly take a slight rise and then would again decrease as the output further increases.

Before coming to the meeting this evening I jotted down a few figures based on actual conditions in two different stations. In the one station as the output increased from 600,000 kilowatts per month to 800,000, the maximum hourly output increasing at the same time from 1500 to 2600 kilowatts, the fuel cost decreased 14%, and the labor cost decreased 32%. If you will figure back from the maximum output you will find that the load factor decreased as this output increased. And yet the generating cost decreased. In the other plant where the monthly output increased from 220,000 kilowatts to 430,000 kilowatts (that is practically doubled), the maximum hourly output remaining practically constant, in other words, the load factor increasing, the decrease in fuel was 35% and the decrease in labor was 44%, showing that the load factor of course helped decrease the generating cost considerably, but that the generating cost will also decrease with increased output even though the load factor becomes poorer.

Mr. Abbott: Mr. S. M. Bushnell has stated that he had a good deal of trouble in fixing rates for large consumers; I wonder if he could add something to the discussion?

Mr. S. M. Bushnell, M.W.S.E.: I don't know that there is anything I can add, except to emphasize one point which perhaps has been overlooked a little tonight. We have been speaking largely from the standpoint of the central station,—the advantage of a variable system of rates from that standpoint. But I think we also ought to speak of the advantage to the customer, the man who is to use the power, of having such a system of rates as that outlined this evening. I have had occasion, a great many times, to take up the question of the cost of running a small plant, and perhaps an approximate estimate would run something like this: The fixed charges would run half and the operating cost would run the other half, and of this operating cost perhaps the coal bill would be about half. In other words, the coal would be about one fourth of the whole cost. Now the man who is figuring on whether he would use power or not will come up against a proposition like this in figuring on a flat rate. On a proper estimate of consumption, the rate which he will get will make him a saving, but as he considers the question as to how much power is he going to use, he is likely to over estimate the amount of power to be used. I find in nine cases out of ten the tendency is to over estimate rather than to under estimate the amount of power to be used. Supposing he estimates the current consumption just double what it will actually run, he would add possibly one fourth to the cost of the operation in his plant, that is he will double the amount of his coal bill while the cost from a central station would be doubled if figured on a fixed price. This system of charging that has been

outlined tonight, enables him to figure out under any condition, what his rate will be and gives him an elastic system which will correspond with the conditions under which he will operate his plant.

Mr. Abbott: Is there any other discussion? If not, I will ask the gentlemen who presented the original papers to submit their closing. I will ask Mr. Waring to speak first.

Mr. Waring: I don't think I can say anything more; the subject seems to have been pretty fully covered, so I will leave it with the other gentlemen.

Mr. Abbott: Mr. Lloyd, will you add something?

Mr. Lloyd: There is very little to add to what has been said this evening, except on the point brought out by Mr. Postel, that there is a possibility of small central stations improving their load factor by taking business off the peak. In a small town it is possible to watch all the industries on the central station closely to see that they live up to their agreements, and has been done in some cities. In the city of Chicago, where the Central Station Company is serving over 80,000 customers, it is impossible to establish, at least at this time, a system of rates that will cover such conditions. I believe such systems were in use in Montreal, but I also believe that in certain months of the year the consumers disregarded their agreement and ran on the peak any way. And again, any central station company developing a business in a large center like this, finds it possible to make lower rates where there is a wide diversity in the maximum demand of different industries; much lower rates than they could possibly make if they tried to use a system of rates based on off-peak business.

Mr. Abbott: This closes the discussion of these papers this evening. I think you will all agree that the experiment of a joint meeting of the two organizations here represented has been such a success as to warrant a repetition of the experiment at some favorable time. There being nothing more to come before the meeting, it stands adjourned.

REMINISCENCE MEETING

March 24, 1909.

President Allen: The Western Society of Engineers, or rather its parent body—the Civil Engineers' Club of the Northwest—was organized in this city nearly forty years ago, and we have therefore called our membership together this evening for a Reminiscence meeting, to hear from those who organized and conducted the affairs of our Society during its early history.

We are fortunate in having a number of our older members with us this evening, and I wish to assure them that this meeting will be in their hands and that they have the privilege of the house.

And first let me call upon Mr. L. P. Morehouse, the first Secretary of the Civil Engineers' Club of the Northwest, who will make the opening address.

Mr. L. P. Morehouse, HON. M.W.S.E.: I do not now that I am really glad to appear before you this evening, because it is embarrassing for a man not accustomed to public speaking to stand on a high platform and try to talk to such an audience as this. I was requested to come here to-night, however, and I may say that as a general proposition whenever I have been asked to do anything for the Western Society of Engineers and for its predecessor in name, The Civil Engineers' Club of the Northwest, I have always responded to the best of my ability. But there is another source of embarrassment. I suppose most of you know the story about John and the cats. John said, "Grandma, did you hear the cats last night?" to which the grandmother responded that she did not. John said, "Why, Grandma, there were a *thousand* of them!" But the grandmother assured him quietly that he must be mistaken, for a thousand cats were a good many. John then said, "Well, Grandma, there were a *hundred*!" To this the grandmother said that even a hundred were a good many. John then very modestly replied, "Well, anyway there were two because I saw them."

When I was asked to come here and say something to you about the early history of this organization I said that I had told it about a thousand times. Then I thought of John and said, "Well, I have told it at least a hundred times," but upon referring to the records, where I thought I would find a statement of how many times I had talked on this subject, I found evidence of only two instances.

In the first instance I seem to have posed before you as a historian; the next time I intimate that I should have been a poet; to-night I ought to come, perhaps, as a writer of fiction founded on fact. It is probable that most of the people who are here this evening were not present on the previous reminiscent occasions, and I do not know that I can do better than to stick to what I am reported as having said before.

In my previous remarks, published in the *JOURNAL* of February, 1900, I said that the beginning of this organization was on May 25, 1869. I will quote a paragraph which I quoted at that time from the minutes of that meeting:

"In pursuance of an invitation to them and to other civil engineers, from Col. R. B. Mason, the following named gentlemen met at No. 13 Dickey's Building, Chicago, on the evening of Tuesday, May, 25, 1869: R. B. Mason, I. C. Chesbrough, H. A. Gardner, Charles Paine, L. H. Clarke, William Bryson, K. F. Booth, Wm. H. Clarke, Max Hjortsberg, George C. Morgan, A. L. Van Meenen, and L. P. Morehouse."

Of these gentlemen, besides myself, I think Mr. Morgan is the only one still living. The last time I saw him—about a year ago—he was expecting to go to California, and my impression is that he is there now, building water-works as he did in Chicago.

For the benefit of those who do not know who these gentlemen were I will say:

R. B. Mason at that time, and for some years afterward, was called the Dean of the engineering profession in the northwest. He was probably the most widely known there of any civil engineer. He came to Illinois in 1851 as chief engineer of the Illinois Central Railroad and for six years was building that road. After its completion he went into business as a contractor. He built one or two roads in Iowa, and then returned to Chicago to practice his profession in a general way. In 1869 the principal work he was engaged on was the construction of the Dunleith and Dubuque bridge over the Mississippi river, which I think was begun in the spring of that year and completed in December. The next year he was made chief engineer on the work of deepening the Illinois and Michigan canal so as to take the water from the Chicago river and provide a new method of disposal of the sewage of the City of Chicago. He was Mayor of Chicago at the time of the great fire, having been elected a year after our Society was organized.

I. C. Chesbrough was a brother of E. S. Chesbrough and was connected with the engineer department of the City of Chicago. H. A. Gardner was chief engineer of the Michigan Central Railroad. Charles Paine was division engineer on the Lake Shore and Michigan Southern Railway. I will state here that Mr. Paine was the father of this Society, and while the invitation to attend the first meeting went out in the name of Col. Mason because he was so well known, Mr. Paine was really the founder. As many of you know, he filled some very important positions in the engineering world. He left Chicago to become general superintendent of the Lake Shore and Michigan Southern Railway, resigning that position to take that of chief engineer to build the West Shore road.

L. H. Clarke was chief engineer of the Illinois Central Railroad. He afterwards filled several positions of a similar character, going from the Illinois Central in 1877 to the Lake Shore and Michigan

Southern as chief engineer. At one time he was city engineer of Chicago. Mr. Bryson was connected with the engineer department of the City of Chicago. Mr. Booth was chief engineer of the Chicago and Alton Railroad. W. H. Clarke was connected with the engineering department of the City of Chicago, and was the engineer in charge of the first tunnel that was constructed under the lake. Mr. E. S. Chesbrough, city engineer, was the designer of the tunnel and advanced what was then considered the wild idea of going out two miles under Lake Michigan to obtain pure water for Chicago. I should like to say that he was present at our first meeting, but the records do not sustain me.

Mr. Hjortsberg was chief engineer of the Chicago, Burlington and Quincy Railroad. Mr. Morgan was in private practice, I think. Mr. Van Meenen was chief engineer of the Chicago and Northwestern Railway. Mr. Morehouse was assistant engineer on the Illinois Central Railroad.

These are the people who were present at the first meeting and when we remember that it was forty years ago, it gives some little interest to the matter.

Referring again to the minutes of that meeting as printed in the JOURNAL, I find it recorded: "Resolved, that we, the civil engineers of Chicago here assembled, now form a club to be called The Civil Engineers' Club of Chicago." I had never noticed this wording of that resolution until a few days ago; "we, *the* civil engineers of Chicago." In going back to the original minutes, however, I found, much to my relief, that the printer had carelessly inserted the word "the," and that this word does not appear in the original record.

After this resolution a committee was appointed to report a plan of organization at the next meeting and that committee discharged its duty.

Further in the records we find that Mr. Paine offered a resolution, which was unanimously adopted, "That the Secretary is hereby directed to prepare an alphabetical list of the names of the members of the Club, and that each member be required to present to the Club in his turn a paper upon some professional subject to be chosen by himself, one paper to be read at each meeting." Resolution 2: "That any member whose turn it may be to supply a paper shall be notified thereof by the Secretary as soon after the monthly meeting which precedes his turn as may be, and such member shall be responsible for the reading of the paper at the next monthly meeting; and if for any cause he shall be unable to read a paper it shall be incumbent upon him to procure a substitute who will read one, and to notify the Secretary of the name of the substitute for the evening."

Now let us see how these resolutions worked. The first name on the list began with B—Mr. Blunt: he presented a paper on the subject of Railroad Frogs, which I remember produced considerable discussion. To Mr. Blunt is due the honor of presenting the first

paper before the Society, and as most of you know, Mr. Blunt takes almost as much interest in the Society at the present time as he did at that time.

Shortly after the resolutions above referred to, we find the following record in the minutes: "The Secretary read a letter from Mr. Robert Harris, sending in his resignation as a member." After discussion of the matter and upon motion it was resolved, "That the Secretary be directed to inform Mr. Harris that his name begins with 'H' and that a long time was before him before he would be called on for a paper, and that his resignation would not be accepted."

The Society seemed to be in a comfortable condition in this early period; for instance, the Club was organized in May, and in December of that year it was resolved, "That the Secretary be and hereby is directed to suspend, until further action of the Club, the collection of the initiation fee provided for by the constitution." It is noted in this connection that "nobody had paid any initiation fee up to that time and that nobody had paid any dues. We were in a very prosperous condition." Very soon after this, the records show that the Secretary, at the request of several members, "had directed that a collation be served at the close of the business meeting." Also that, "upon motion it was resolved that the action of the Secretary be endorsed and that he be empowered to pay for the collation."

I quote again from the JOURNAL report:

"We held our meetings at that time in the club rooms of the Sherman House, for which no charge was made; so, when the year came to a close we thought it proper to give a collation, as we called it, at the Sherman House, and give the proprietors the benefit of what they might get out of that by way of paying the rent. So, for several years we gave a 'collation' at the expense of the Club and for the benefit of the proprietors of the Sherman House."

"I find that the gentleman who made the first payment in money to the Society was Mr. Chanute, but the money was promptly refunded to him as he had not been present at a meeting."

I should have referred to a resolution to the effect that dues should be collected from each member for the current year, payable at the first regular meeting at which he might be present, and the gentlemen who had paid dues and had not attended a meeting had their dues refunded to them. The result was that when a member attended the first meeting he was called upon to pay dues, which looked like fining him for being present.

It might seem a little singular not to find the names of persons on the list that you would suppose would be on the roll, but the explanation is that those gentlemen did not come to a meeting for several months after they were members, and therefore the names do not appear in the Treasurer's list (the Secretary and Treasurer were one person then) until after they had attended a meeting.

After the meeting of January 13, 1873, referred to in the proceed-

ings of the Society, February, 1900, page 56, the Club held its meetings in the Rookery.

We all know what the Rookery building means today, but in those days the Rookery did not mean what it does now. The first name was simply "The Tank." The tank which afterwards became the Rookery was a reservoir, an iron tank built by the City of Chicago in about 1852, when the water-works were being constructed here, and that tank as a reservoir had been used for many years. Still, it was considerable of a building and after the fire the City built some temporary brick buildings around this tank, known as the City Hall. We remained in The Tank until September, and we found it a cool place for the summer. We then went back to the Academy of Sciences, but this time we had more comfortable quarters than a doorway; we assembled there for about a year. Then we made arrangements with the Chicago Chapter of the American Institute of Architects. That was the first time we paid rent for our rooms, and we were then independent of the hospitality of other people. Later on we went to the rooms of the Chicago Athenaeum, where we had very comfortable quarters for quite a while. From there we went to the Honore block, occupied then by the Western Railroad Association. After that we made changes from time to time, which are not at all interesting now.

I think I will close with words which I used on the previous "reminiscence" occasion; they are just as appropriate now, gentlemen, as they were then, and they will be just as appropriate as long as I live:—

"I cannot refrain from adding at this time that in all the years of my connection with this Society and my association with the different members, many of whom I have known so well, it has been one of the greatest pleasures of my life to see not only the physical works which many of these gentlemen have superintended or carried out—the works which will remain after they have passed away—but to have associated with these gentlemen who have made a record in their personal lives, and placed before the community the evidence that engineers can make, not only monuments of stone and of metal that shall endure, but shall make, can make, do make, character for themselves, the remembrance of which will not be forgotten by their friends or by any community in which they may live."

President Allen: We are glad to find out where the modern methods of "frenzied finance" had their beginning. Many modern Captains of Industry would give a good deal to learn the secret through which all bills were paid and obligations met without the collection of any dues. Perhaps some of our other distinguished members can tell us more about the methods and ways of doing this. Personally I am glad that the method of assigning the writing of papers alphabetically is not in vogue in these days, as I should have to come in quite early in the "game."

Our Society has had a long and varied career, and these quarters that you see here are evidence of prosperity, but whether we have increased in quality of membership and personal attainments as we have in wealth is another question.

We have with us this evening one of our oldest members, who has come all the way from Tennessee to attend the meeting, and we are much pleased to welcome him. I take great pleasure in introducing Mr. C. H. Hudson.

Mr. C. H. Hudson, M.W.S.E.: I have been asked to present on this occasion some remarks relating to the early days of this society, and will venture a few words, notwithstanding the fact that public speaking is not one of the strongholds of the profession.

Forty years have passed since a small company of gentlemen, in the city of Chicago, met and formed the Engineers Club, which has grown into your present society. They had in view largely the social features of such an organization, though incidentally expecting, no doubt, that they would derive some professional benefit from it.

These gentlemen were of high character, engineers of ability, and many of them then of national reputation. Prominent among them we find the names of Col. R. B. Mason, the first President of the Club, well known in those days in connection with the Illinois & Michigan Canal, as well as with the early development of Chicago; Mr. E. S. Chesbrough, the father of the Water and Sewer System of Chicago, in the development of which he spent many of the best years of his life; Mr. D. W. C. Cregier, an able assistant of Mr. Chesbrough; Mr. E. B. Talcott, an important factor in the Chicago & North Western Railway in its early days; Mr. Robert Harris, then at the head of the Chicago, Burlington & Quincy Railroad, and in the later years of his life active in the management of the Erie and the Northern Pacific Railways; and Mr. Charles Paine, of the Lake Shore and Michigan Southern Ry.

These and many others have passed away, but there were also men younger in years, who are still with us, and who have continued during all these years to contribute not only to the expansion and development of your society, but also to the general advancement of the Profession. Among those are names familiar to you, Mr. L. P. Morehouse for twenty years the honored secretary of your society; Mr. John E. Blunt; Mr. Walter Katte and Mr. Octave Chanute; all now veterans of large experience and ability.

Such men as these formed your society, which with their aid, and the aid of others of like character, has grown in extent and usefulness until now it numbers upwards of one thousand, and as a factor in the Engineering World, stands second to none. Its members are found in every clime from the Atlantic Ocean to China, the Philippines and New Zealand; and from Hudson's Bay to Brazil.

It was my good fortune to join the Club in 1876, or seven years after its organization; and I am ranked to-day among the older living

members. I think there are an even dozen who have been longer with the society than have I. Among these I find the name of Mr. D. J. Whittemore, of the Chicago, Milwaukee & St. Paul Ry., and under whom it was my pleasure to serve in my early life.

Mr. Whittemore's position today is a very unusual and unique one, he having served the same interests upwards of half a century, during which time it has been his privilege to condemn some of his earlier work and rebuild it on better lines. It is to be hoped that he has been charitable towards the original constructor, knowing as he must, the conditions and restrictions under which the work of the earlier day was done.

Other names, prominent in the Engineering world, who have been active in your society, some still active and some of the 'silent majority' might be added did time permit.

That your society has played an important part in the advancement of the science of Engineering is unquestioned; and that it will continue to exert a strong influence in the same line is equally certain.

It is quite likely that some of the younger of our members do not fully appreciate the changes that have taken place during these forty years of the existence of our society. In those early days there was little of the specializing that we see today, but the Engineer had to tackle all sorts of problems, whether mechanical, mining, sanitary or other character, and very frequently upon lines that had not been 'threshed out' so to speak. He had to grope in the dark, study the matter under consideration, and use his own judgment, and I may add with truth, his *Nerve*, for not unfrequently there was some question as to the final results, and it required a man of nerve to confidently take the risks which sometimes seemed necessary to accomplish the desired end.

The original Lake Tunnel of Mr. Chesbrough, built fifty years ago, modest though it is when compared with those of recent years, was in a new field, and was more of an undertaking at that time, than are the modern and more extensive ones today, with the light of the fifty years' of experience to guide the builders.

There is no more hesitancy today in undertaking the proposed Subway from the Catskills for the New York Water Supply, than there was in undertaking the original construction of the Croton Water Works, though as an engineering question the Subway plan is vastly more difficult.

I think some of the older of our members could tell interesting tales of their trials and experiences in their early work in partially explored fields. For instance in connection with the bridging some of our larger western rivers.

Because of their experiences, however, the same problems can be more easily handled today, and quite likely at less cost.

Subjects that are now laid down in the books quite fully, and in which instruction by able teachers can be had in all our technical

schools, were in the olden time not touched upon, or at best but vaguely treated, with little to guide the student, beyond the generalities. He had to be satisfied with the little light given, and then apply the principles as his judgment dictated or guided him.

The Founders of our society builded better than they knew, and their achievements should, and doubtless will inspire the younger of our members, and those that are to come, to equally good work, not only for their own pleasure, but for the benefit of those who are to follow them.

President Allen: We have with us this evening Mr. Benezette Williams, who served as President of this Society during the year 1885. We should like to hear from him.

Mr. Benezette Williams, M.W.S.E.: I came to listen to what others might say, rather than to speak myself, and I do not think I can add much to what our friend Mr. Morehouse has said. When I joined the Society in 1873 Mr. Morehouse was Secretary, and a more diligent and faithful one it would be hard to find. The account given by him this evening of his efforts to find the rooms of the Academy of Sciences is evidence of that. Among the early members alluded to by Mr. Morehouse were some notable men, especially Mr. Chesbrough, Mr. Mason, and Mr. Paine. I served as an assistant to Mr. Chesbrough for a number of years and know that his high standing as an engineer and a man was fully merited. This Society has had the honor of producing, so to speak, two Mayors,—Col. Mason and Mr. Cregier.

I believe Mr. Morehouse failed to mention the very excellent quarters which we occupied for a time in the American Express Company's building. These were by far the best rooms that the Society occupied prior to locating in the Monadnock building.

The present large membership of the Society brings to mind the many years that the membership was not sufficient to properly maintain permanent quarters and that when we reached 300 it seemed a great achievement. Chicago having become a great industrial center for engineering matters of all kinds the more than trebled membership is easier kept than 300, twenty-five years ago.

While I have not been able to attend as many meetings of late as I should like, my interest is still just as great as ever.

President Allen: I regret very greatly that all of the surviving members of our early organization could not have been here this evening, but we have received letters from many of those who could not come. These letters have been received from all parts of the country and indicate that those members still think of our Society and have a warm place for it in their hearts. We shall now have the pleasure of hearing these letters, which will be read by the Secretary.

Mr. Richard Price Morgan, M.W.S.E., Dwight, Ill. (by letter): I very much regret that I cannot be with the "Elders" of our Society

April, 1909

tomorrow night. I am quite sure I am old enough, but other conditions debar me from the pleasure.

I could tell two or three hundred yarns myself, some of them not so bad as they might be. I wish for all, a good social time full of honor and utterly without money profit.

The address of Gen. Dodge was very interesting to me and will be instructive to younger members.

[An interesting letter to Mr. Morgan, from President Lincoln, has been reproduced in fac-simile in Mr. Morgan's letter paper and is here printed as of historical value.]

EXECUTIVE MANSION.

Washington, D. C., October 16, 1863.

To the Officers of the Pacific Railroad:

Richard P. Morgan, bearer of this, is my personal acquaintance and friend, whom I would like to have obliged in any reasonable way. I became acquainted with him, while he was acting as a Railroad Civil Engineer, and I knew him long enough and well enough in this capacity to believe him to be both competent and faithful.

Yours, etc.,

A. LINCOLN.

Mr. T. J. Nicholl, M.W.S.E., New York (by letter): It gives me great pleasure to respond to your very kind invitation to be present at the reunion of the Western Society of Engineers on the evening of March 24, 1909. It will simply be out of the question for me to be with you in person, the loss however will be mine, and I shall do the next best thing, by writing and wishing you all good cheer, etc.

In looking over the official list of active members, I see that my membership dates back to September 10, 1872, also that there are still alive only seven of the original members of the Civil Engineers Club of the Northwest of older dates than mine, namely Messrs. L. P. Morehouse, John E. Blunt, O. Chanute, A. Comstock, Walter Katte, A. W. Paige and D. J. Whittemore. Benezette Williams was made a member about one month after me.

If my memory serves me rightly, we had about forty members when I was proposed, and nearly all of them have passed to "the great beyond" since then, but, it is to the untiring energy and hard work of such men as Col. R. B. Mason, E. S. Chesbrough, L. H. Clark, Max Hjortsberg, K. F. Booth, D. C. Cregier and L. P. Morehouse that the present society of over one thousand members owes its greatness. Who will ever forget these great and good men who laid our foundations so well and true. Well may we be proud of our society and wish it success in the future.

We had our headquarters in so many places that I cannot recollect the names of streets or the numbers, but, I do recollect one

meeting we held out of doors altogether, in a severe snow storm, somewhere on State Street, I think near Washington, Mr. Morehouse and about three others in addition to your humble servant were present. The meeting was held in a doorway by the light of matches. I cannot recall why it was held there, but, the Secretary had either left his key at home, the storm was so bad we could not find the room, or else we were not inclined to go to it; at all events, the Secretary kept a record of the meeting. It seems to me that E. S. Cheshbrough was also present on that occasion as he was President, and I also believe we elected some new member that night, which, of course, the records will show. No doubt Mr. Morehouse will remember the meeting well. Alas! time has brought wonderful changes both in our little society as well as the great city where it was born. I have in mind my first paper about the seventh or eighth ever read before the club. It was in a very small room, I think, on Randolph Street, and the subject was "Rapid Transit in Cities." Think of it, and also think of the nerve of me, a mere boy, reading a paper upon such a tremendous subject, before such men as above referred to, all of whom were there and several others. Especially do I recollect Mr Robert Harris (he was a member I believe, but not listed amongst the deceased), at that time President of the C. B. & Q. Ry., and afterwards of the Northern Pacific, because he made some lengthy and very pertinent remarks on the subject. Now, if the City of New York had, at that time, built subways instead of elevated railways, what a Godsend it would have been to the present inhabitants. Still at that time, I favored the elevated railways because; 1st, I did not understand what a nuisance they were; 2nd, I had no idea of beauty, as related to the growth of cities; 3d, they were cheaper; 4th, no one ever supposed that New York would outgrow their usefulness. Besides all this, I simply knew what I had read or heard about the celebrated Greenwich Street Railroad, but enough of this. "What might have been" is dead, and let us hope that our Engineers of the future, will think well before they recommend or try to make the public pay for their mistakes. Great reputations and supposed success have caused, and I suppose will yet cause, many a national as well as a municipal error.

Now, as regards my personal experience about the time of the beginning of the Western Society, let me say just a few words. In early life I was with my father who was a Division Engineer on the Grand Trunk Railway of Canada. I came to Chicago a poor boy in 1867, soon after the close of the war, with about \$100, in old and well worn "shin plasters," as dirty and ragged as any money ever was, but, it secured board and lodging in the last house on State Street, corner of 31st and near where the Douglas Camp of Southern prisoners used to be, also where you changed from horse cars to the steam dummy for the Stock Yards. It was some time before I got employment, but I succeeded at last in architects office (Mr. Wad-

skier's). Then I changed to Foster & Swift, surveyors office, and S. S. Greeley with whom I made many city surveys; was often at the old red cedar stake marking section corner at State and Madison Streets. Laid out the village of Washington Heights and Norwood, also part of Riverside with Messrs. Olmsted & Vaux, after which I was employed by Max Hjortsberg to go to Galva, Illinois, and acted as Division Engineer until that branch of C. B. & Q. was completed to New Boston. Then went to Bloomington, Illinois, as Assistant Chief Engineer under Col. R. P. Morgan of the Lafayette, Bloomington & Mississippi Railway and through whose influence I afterwards became Chief Engineer of the Plymouth, Kankakee & Pacific (now the three I's Ry.). Nearly all this time I lived in or near Chicago and was in constant touch with the Engineers Club of the Northwest, since which time my experience has been so varied and so far reaching, that it would not be interesting to the Society.

Let me say, in conclusion, that the Society has done me a great deal of good even in its small days and it cannot fail to be a great assistance to the future generations of the West. The American Society has its work in the East, but, how much greater is the West in every respect, besides the West is truly American.

Mr. Walter Katte, M.W.S.E., Irvington-on-the-Hudson, N. Y. (by letter): I regret very much my inability to be present, in person, on the occasion of the "Reminiscent Reunion" of the members of the Western Society of Engineers, to be held on the evening of March 24th. Had it been possible, I am sure nothing could have given me more gratification than the pleasure of spending this evening with you, and in once more cordially greeting the little band of only some four or five of us now left, of the less than a round dozen, who participated in the planting of the little seed some forty years ago, which has proved to be the nucleus from which has been evolved your stalwart institution of 1909.

Although your earliest elective membership bears date of about the middle of 1869, if my present recollection is not at fault, the inception really occurred in the latter part of 1868 and early in 1869, when after it had been talked over from time to time privately, between a few of us of the engineering fraternity living in Chicago, we decided to try and get up a little meeting in order to draw out a consensus of opinion on the subject. We succeeded in getting together one evening, about a dozen, I think, and held our meeting in a little back parlor of the old—"before the fire"—Sherman House. This meeting was attended, as far as I can now remember, by Col. R. B. Mason (your first President), Mr. Morehouse (your first Secretary), and Messrs. Chesbrough, Booth, Blunt, W. H. Clark, Hjortsberg, Pope, Paine, Chanute, O. B. Green and myself.

We found the sentiment unanimously and warmly in favor of trying to effect an organization of some kind, either club, association or society for the mutual benefit and improvement, professionally

and socially, of the whole body of the engineering fraternity of the Northwest, and especially of those residing in, and in the vicinity of Chicago, and those to whom Chicago was their natural business center.

As to the measure of success which attended and resulted from this little beginning, words from me are quite superfluous to the present membership of the Western Society of Engineers. An initial organization was effected in the spring of 1869 under the name of the "Civil Engineers Club of the Northwest," if my memory serves me right, and from that time until now its progress has been "onward and upward," so that to-day it stands a most notable example of the truth of the old saying, "great oaks from little acorns grow," and can proudly point to its own record as its best monument.

I will not tire you with any further reminiscences of those early days; indeed, it would be a work of supererogation on my part to do so, while you have still with you so able an historian, in the person of my old friend, Mr. Morehouse. Personally, I was able to do but very little to advance the interests of the young Society after these early days, owing to my being obliged to take up my residence in St. Louis in order to take personal charge of the erection of the Eads steel arch bridge superstructure, which occupied my entire attention for over four years, and subsequent removal to New York in fulfillment of professional engagements upon the New York Elevated, New York, West Shore and Buffalo, and New York Central and Hudson River railroads. This widened the breach separating me from you, notwithstanding which, permit me to assure you, that my interest in the progressive welfare of this "tall oak" which has grown from the little acorn, I helped a little to plant, forty years ago, has remained unbroken from then until now and I am proud of being able to subscribe myself a "Life Member" of the Western Society of Engineers, and of being one of the very few left now of its "old guard" of 1868-9. Although I am unavoidably absent in person to-night, I beg to assure you of my presence in spirit and cordial sympathy.

In conclusion, permit me to beg the privilege of proposing the "silent toast" to the memory of the many of that "old guard" of 1868 who have "passed over to the other side," in grateful recollection of the work they did in laying the foundations of your noble institution.

I extend to all present my most fraternal felicitations and congratulations.

Mr. L. P. Morehouse · I was unable to mention any names except those who appeared on record as having been present at the first meeting, but it would be a great injustice to a number of gentlemen if it is not understood that they were not only in hearty sympathy with the starting of this organization, but that they were connected with its actual proposal. Mr. Katte refers to a meeting in the Sherman House, which he thinks was in 1868. He is perfectly right there. I have read to you from the official record of the Society to the effect that the first meeting was held in May, 1869, but

I am well aware that Mr. Katte, although not present at that meeting, was one of the gentlemen who was thoroughly desirous of having such an organization as this, and the meeting he refers to was held in the Sherman House prior to the meeting of May, 1869, when the Society was officially organized.

Alonzo W. Paige, M.W.S.E., New York (by letter): I have your valued letter of the 4th inst., forwarded to me from Schenectady.

Interesting, very interesting it would be to me to meet with you on Wednesday evening, March 24th, to talk over the early days of the W. S. E. Alas! engagements here will prevent my going to Chicago, but I shall be with you in spirit. That same spirit of pride and interest in the Society of Western Engineers that was so keen among its members in those early days, I am sure still continues with the few of us older members who are still living; an even added interest and pride, let me say, since you have grown in strength and are better able to promote and aid an exalted profession, a profession so all-important in this age of development and progress going on in the world.

I know full well that the evening of March 24th will be interesting and instructive, and I am sorry I cannot be with you. I thank you for the invitation, however, and send my best wishes for the continued success of the Society.

Mr. L. P. Morehouse: I will say in this connection that my recollection is that Mr. Paige wrote the second paper presented to the Society. His name begins with a "P," but he appeared as proxy for Mr. E. S. Chesbrough, who was scheduled for the second paper but was unable to present one. Mr. Paige read an article on the construction of the Hudson and Mohawk Railroad—a road, probably, that most of you have never heard about; it was the easterly sixteen miles of what is now the New York Central Railroad, and was built about 1830.

Mr. A. W. Wright, M.W.S.E., Pomona, Cal. (by letter): I regret exceedingly that I cannot be present at the "Reminiscence" meeting, for it would afford me the greatest pleasure to meet my old friends who survive, and hear of those who have left us in their bodily presence but who survive in the memory of those still living.

In 1879, the "Civil Engineers Club of the Northwest" ceased to exist and was succeeded by the "Western Society of Engineers." This change was not effected without opposition. Three distinguished members, Charles Latimer, L. H. Clark and Charles Paine, headed the opposition. But who could meet and know those men without loving them? Each did noble work upon the great railroads of this, our great country.

I had the honor of reading my first paper before the Society on February 3, 1880. It was, "Extracts from the Early History of Chicago Railroads." I devoted much time and study to this matter and ran across interesting facts.

It was very difficult in those days to obtain any papers for the Society. In 1886, when I was honored by the Presidency of the Society, I appointed a committee to secure papers, and I personally called upon every resident member, urging more interest in the Society and requesting papers. When no paper was in hand, I wrote one myself, for several years, which is the reason that so many appeared from my pen.

No reminiscence of this Society will omit the name of L. P. Morehouse, for to no one other member is the Society so greatly indebted. At the first meeting, when the Civil Engineers Club of the Northwest was organized, with Col. R. B. Mason as President, Mr. Morehouse was made Secretary, an office he filled with ability and faithfulness until January 3, 1888. Time and again I believe the Society would have perished had it not been for his devotion, his ceaseless and untiring efforts.

Your list of living and deceased members contains the names of many men distinguished for their professional services. The value of the work they performed and their far-seeing plans for the future, which the passing years are seeing reduced to actualities, cannot be measured in dollars and cents. So far as their pecuniary rewards are concerned, few have prospered as their merits warranted. They did not have the requirements for money-getting as is said to have been defined by our great Lincoln, who had no admiration for mere financial success, namely, that—"Financial success is purely metallic. The man who gains it has four metallic attributes; gold in his palm, silver on his tongue, brass in his face, and iron in his heart."

Thank God these requisites were lacking among the members of our Society, and I know of no instance when anyone failed to respond and to assist another so far as in him laid.

I trust that the meeting may call together many of the oldest members.

Mr. John W. Weston, M.W.S.E. Fennville, Mich. (by letter): I find it no easy task to conjure up the memory to detail reminiscences of the earlier days of the Society, for the reason that the present successful career of the organization, with its wealth of interesting and inspiring incidents, tends to obliterate or, at least, consign to the background the experiences and happenings of years ago, in the days when it looked frequently as though the Society would never attain prominence. But that was at a time when only the most fervid imaginations ever dreamed of a two million Chicago in their lifetime.

It is, indeed, to me hard to realize, after reading the report of the late annual meeting, that this is the same organization as the old Civil Engineers Club of the Northwest, so far as, one might say, the personnel is concerned. And it may be confidently asserted that only devotion to the profession of certain well-known and highly respected members who, faithful to the idea that organized professional intercourse must be maintained for mutual benefit and

progress, kept the Society an effective force in the engineering world of the Middle West. None interested can doubt that it has been any other than an effective force when a thought is given to the quality and variety of papers, though comparatively few in number, read in those times. They dealt with the public engineering problems of the day—problems which had to be solved by civil engineers.

In the interesting address of Mr. Morehouse at the annual meeting, held January 2, 1890, and of Mr. Chanute, at that of January 7, 1902, the history of the Society, from its birth on the 25th of May, 1869, to the latter date was so interestingly and fully told, that I realize how little I can add to merit further attention.

I can remember my attendance on the first meeting, in 1877, at which I was entitled to be present, having been elected to membership under the guidance of Mr. George H. Frost, whom I was assisting in the office of the "Engineering News," then published in Chicago. It was not a large meeting as may well be understood, but Mr. E. S. Chesbrough was president at the time, and all who remember his professional suggestions presented with the forceful urbanity of his gentle nature, will understand the affectionate memory in which he is held by those who knew him. A word of digression as exemplifying human characteristics. I had occasion to call upon Mr. Chesbrough in his office after his resignation as City Chief Engineer of Chicago, which resignation was brought about by very questionable means as we all thought at the time. He was once more picking up the trails of private practice and, in speaking of business prospects he remarked that a prominent alderman had quite recently called upon him, and asked his advice on certain engineering matters connected with the city. With the peculiar modesty and hesitancy natural to him when the subject was personal, he told me he felt it his duty to suggest to the alderman that he was now making his living by his advice on professional subjects. But by the manner in which he related the incident it was evident that he would much rather give the advice free of charge under the circumstances.

The discussion on the adoption of the Metric System, of which a committee was given charge in 1876, resulted in a final favorable report which was presented by Mr. S. S. Greely, chairman, on May 6, 1879. This, however, did not end a subject which had been a long time under serious discussion by many prominent members. The Boston Society had initiated the matter, and the opposition had been very determined, Mr. Charles Latimer, of Cleveland, leading. I do not remember what the final outcome was, but I was in opposition, based on a belief that we should adopt our own most popular standard and decimalize on that. My opinion was largely induced by having worked in the French system when railroading in my engineering infancy in Sicily, with headquarters in the fine but ill-fated city of Messina. This was a country of diverse weights and meas-

ures which did considerable "mixing" with what we had been raised upon. It appears yet that the opposition had it, but the interest on both sides of the question was quite intense, and added considerable zest to the meetings.

The year 1880 was particularly marked by the reception and banquet given by the Society to Count de Lesseps. As usual during the secretaryship of Mr. Morehouse, the work of preparing for this function fell largely upon him. The question of working up a little French for the occasion was a weighty problem to many which, in in numerous instances, resolved itself into a very pronounced improvement in the art of "speech without words" and the resort to frequent bows to indicate a thorough understanding of the situation if not of the remark.

Reorganization was another important act of the Society, consummated on June 1st, 1880, by the adoption of the resolutions covering the question. This had been a hard campaign on the part of the promoters, for the opposition comprised many of the prominent members, who undoubtedly by long association as members of the Civil Engineers Club of the Northwest looked upon that organization as amply broad enough for all future development. Mr. C. W. Durham devoted himself in every way possible to the end of winning the fight, and I well remember his burst of indignation when, at the meeting to vote upon the question, many of the older members whose presence was seldom recorded, appeared upon the scene to vote against the project. I do not think that the Society ever came nearer adopting current political methods to secure an end, than in the final efforts to change the organization of the Society. None can now doubt the wisdom of the change; though only theoretically was the field enlarged, for a change in policy and effort were soon developed with results which speak for themselves.

When one looks back upon the period of 1878-81, it carries the conviction of great activity, for beside the two campaigns of discussion alluded to, the question of the Association of Engineering Societies, for the joint publication of proceedings and papers, came up in such form as to demand the serious attention of the Society. It was advocated and opposed with much earnestness on either side. As associate editor of "The American Engineer," published at that time by our esteemed member, Mr. Willard A. Smith, a proposition was made to the Society which seemed to me to offer advantages over the joint publication scheme, and I became active in opposition. It had always appeared to me that the Western Society would outgrow the purely local organizations scattered over the country and would best consult its future interests by standing alone, and although I afterward became secretary of the joint publication, in looking back I feel that the impression was always vivid in my mind that when the Western Society was strong enough, financially and numerically, the publication of its own papers and proceedings would

be the logical outcome. Nor did the question become finally settled until the opposition had secured another vote upon it and thereby failed to convince the majority that secession was advisable.

Mr. Chanute, in his address referred to in the opening of these remarks, gives a very entertaining account of the main incidents, conditions and progress of the Society during the years following 1881.

There were many discouraging periods, however; the upbuilding of the Society in membership seemed a hopeless task, and the faithful few upon whom most of the burden fell had many a conference among themselves upon ways and means to bring about the addition of more members, and several schemes were resorted to with this end in view. The importance of this increase was deemed absolutely essential.

Much to the regret of the Society, Mr. Morehouse, after long and valuable services, felt compelled to resign the secretaryship and Mr. L. E. Cooley was elected to fill the office on January 3, 1888. The ensuing year was again an active one in efforts to promote the interests of the Society and to decide upon plans to extend its influence, and a tentative conclusion was reached that a secretary should be elected whose business would admit of devoting all the time necessary to properly conduct the affairs of the Society; the work of securing new members to be kept a prominent issue. Circumstances transpired to bring about my election to the office (of secretary) on January 8th, 1889, with implied injunctions to devote myself to the interests of the Society with special reference to an increase of membership.

Whether due to the wonderful material progress of Chicago and of the country at large, or the persistent work of the Society in leaving nothing to chance in the search for new members, or both, we still have some 110 members left in the ranks as a result of the missionary efforts of those years. It is confessedly a meagre showing for the work done, and does not nearly represent the total number of recruits gathered in, for the reason perhaps that a certain percentage of new members, morally coerced, as it were, to join the ranks, as readily persuade themselves to resign when occasion offers.

The change in the Society's program for 1889 was inaugurated by a removal to more independent and commodious quarters, always open to the membership during business hours, and what library it possessed in those days soon became a more useful accessory.

The Chicago Drainage Canal and the work on the grounds and buildings in preparation for the World's Fair, of 1893, were subjects large enough in their immense details to afford interesting and instructive topics for professional papers and discussions, and, moreover, gave abundant opportunities for a number of excursions which were indulged in during their progress.

The idea also of providing lunches at the regular meetings and of

issuing invitations to leading citizens when subjects of general interest were on the programs, was once more brought into practice. This time the consensus of opinion among the members, official and otherwise, who were practical participators in the departure, was that such lunches had a marked effect on the attendance. I should like to know if history throughout all the ages ever recorded otherwise? It is certain in our experience at the time, that the flagging zeal of many members was stimulated by a prospect of a lunch to vary the entertainment. And besides this, it was quite a usual thing when a small attendance seemed probable, to sally out and personally urge all accessible members to be sure and be present. Such methods of stimulating a fairly representative meeting are scarcely comprehensible now, although less than twenty years have elapsed since such efforts were necessary.

Publicity at the time referred to was also a potent factor in bringing the Society into prominence, and at every meeting at which any matter of public interest was likely to be brought up, the leading dailies were invited to send representatives, and it is due to them to say that reports of such meetings and doings appeared far more frequently and at greater length than I have noticed for a number of years past. The present position of the Society as a commanding organization does not depend upon newspaper patronage, but twenty years ago it was a far different proposition, and every help consistent with professional ethics to maintain it in public respect, and therefore as a progressive aid to the public good, from the point of view of to-day, seems to have been wisely ordered.

I believe I shall be borne out by all those who did hard practical work for the upbuilding of the Society, in the few years prior to the World's Fair, in the assertion that those years were strenuous ones, filled with many disappointments, but also with many encouragements. It was intensely gratifying to note the rapid development of the organization when once a start had been made, but the start was a long and hard pull. Referring again to the difficulty of securing members, it occurs to me that at one time it was noted that quite a number of members of the American Society were locating in Chicago, and it was deemed advisable to look them up and invite their co-operation with the Western Society, an effort that had not been made a special one. From more than one of these gentlemen I learned personally that they deemed their membership in the American Society sufficient for all practical purposes, and that they saw no benefit to themselves in accepting our invitation. This will throw further light on this problem, in that our field from which to draw membership was included in a sense in that of the American Society, and that this discrimination, so long as it paid, militated against the numerical growth of the younger Western Society.

In conclusion, I cannot help but express the conviction that the Western Society of Engineers as it now stands, owes a debt, beyond

the possibility of liquidation to those old members who, through all the vicissitudes of its early years, remained faithful to their well conceived duty of maintaining it under all conditions and circumstances. It was often a thankless task, requiring zeal of no common order, for even the delight of ministering to a great profession has its drawbacks in the frequent necessity of inspiring fidelity in others, and of keeping the rank and file on the firing line. Their reward is in the Society of to-day, and the consciousness of having contributed so largely to its success. Many of them are now missing from the list of members, but among others who still remain in active service, are such men as: Messrs. L. P. Morehouse, O. Chanute, Lyman E. Cooley, Horace E. Horton, G. A. M. Liljencrantz, Isham Randolph, Don J. Whittemore, Benezette Williams, and A. W. Wright, to whom the gratitude of the Society will ever be in order.

Mr. J. S. Sewall, M.W.S.E., St. Paul, Minn. (by letter): I came to Chicago in the autumn of 1850, having previously had about four years practice in the location and construction of railroads in New England. Any old resident can describe better than I can the low muddy streets, then unpaved, the often floating sidewalks, and all but impassable roads into the country. I lived in the Tremont House, which was then a first class hotel and a most satisfactory residence. I was soon employed as leveler on the railroad location from Fond du Lac to Janesville, and thence to the state line of Illinois towards Chicago.

Early in 1852, I was in charge of the location from Chicago to Janesville. By Chief Engineer Johnson's direction, the line in Chicago was laid out parallel with and four hundred feet from the west bank of the North Branch.

When establishing the long straight lines of the next thirty miles. I was instructed by Mr. Johnson to keep in readiness to make a relocation from the south end of Lake Michigan, keeping clear of the city; but the final order never came. Mr. Johnson advised me to make the maximum rate of ascent going west 0.7 per cent and going east 0.5 per cent.

Early in 1853, when grading was in progress, a new contract was made whereby the contractor was to appoint the chief engineer. This ended Mr. Johnson's connection with the line, and mine. The contractors were allowed to make grades of forty feet per mile.

I could not help knowing that the location I was making was disliked by parties interested in having a cheap line, but Chief Engineer Johnson effectively supported me, and no doubt often got rid of criticism without my knowledge. Once he asked me to make a comparative estimate of the located line, and another line surveyed by some outsider which avoided a heavy embankment by a crooked, roundabout way. It proved that an apparent saving in cost of grading was less than the cost of increased track, the proposed line being a mile longer. Another accusation was that a cut-

ting was made in a place where the ground was lower on both sides. The cut was through a ridge that made an angle of about forty-five degrees with the railroad line. The ground was covered with trees. At one end of the cut the ground was lower on the left and at the other end lower on the right hand.

The Western Society of Engineers was not in existence while I lived at Chicago, or if it was, I never heard of it. Early in 1854 I came to St. Paul, and have only been in Chicago since, to pass through.

President Allen: This has been a fortunate and a delightful occasion. We have had our elder brothers with us, and it is quite fitting that we should receive this message from them to-night.

The profession of an engineer is preëminently a learned one. The popular conception of an engineer as a fighter, struggling against the forces of nature, and either conquering or being swept to destruction by them, is not entirely correct. It is true that the engineer must know how to put up a good fight, on occasions, but we must learn that the forces of nature are the very things that do our work, and the best engineer is the one who takes advantage of them and uses them as his friends instead of his enemies. The closer we keep in touch with these forces and the better we understand them, the greater will be our success. Our battles with nature are mostly due to our failure to understand.

So it is knowledge, understanding, and judgment that makes engineers. The thinker will win out every time as against the man of action, so-called, and this leads to what I want to say of the aims and purposes of our Society. It seems to me that the chief value of this Society lies in teaching engineers to think. We bring up our problems here and discuss them from every side and we profit both from the praise and the criticism, and the bitterest opponents are better friends afterwards for knowing that the other fellow has a pretty good case after all.

I hope we shall never settle, or attempt to settle a single important engineering question. What we desire to develop is men and not creeds or standards.

Our elder brothers have brought us a message this evening, and it is my privilege to reply, on behalf of the Society, that we will endeavor to make their legacy safe in our hands and pledge ourselves to continue our progress to the best of our ability.

The last decade has recorded great progress in this Society, but we must not stop here; there is work to be done. And first I wish to call attention to the necessity of increasing our membership. I hope every member will constitute himself a recruiting committee of one, and will bring in one or more members before the end of the year. We have at present one very prosperous section—the Election Section—why not have sections in other branches of engineering? All this will come with the increase in membership.

Then, we aim to make the JOURNAL of the utmost practical value to engineers generally. We want every member to take particular interest in it and contribute to its pages by bringing his problems before the Society. We improve individually and collectively by bringing up problems and discussing them here. This discussion of engineering subjects is of immense value, and the knowledge of these subjects belongs to the world.

We solicit contributions from our members for the enlarging of our library, and the Board of Direction will authorize the expenditure of such funds as may be available for securing the latest and best books on engineering subjects. Here also progress depends upon our membership. I want to urge that everyone work with us, because it is from the rank and file of the Society that progress must come.

Lastly, let me say that we expect to hold social meetings once in a while, so that the various members may become acquainted.

This closes the business part of our program, and we invite you all now to enjoy yourselves in a social way.

PROCEEDINGS OF THE SOCIETY

MINUTES OF THE MEETINGS.

ELECTRICAL SECTION, March 2, 1909.

A regular meeting (No. 40) of the Electrical Section (being No. 655 of the Society), was held jointly with the Chicago Branch of the American Institute of Electrical Engineers, Tuesday evening, March 2nd.

Past President W. L. Abbott, as Chairman of the Chicago Branch, A. I. E. E., presided, and called the meeting to order at 8:20 p. m. with about 110 present.

As there was no business to bring before the meeting, the Chairman announced the subject—"Relation of Load Factor to Power Costs"—and introduced Mr. E. W. Lloyd, of the Commonwealth Edison Co., who read his paper on this subject. The paper by Mr. C. A. S. Howlett, M.W.S.E., of the Western Electric Co., was presented in his absence by Mr. H. L. Grant of the same company. This was followed by a paper by Mr. J. M. S. Waring, M.W.S.E., of the Electric Storage Battery Co.

Discussion followed from Messrs. J. F. Gilchrist, H. R. King, Wm. B. Jackson, G. H. Atkin, P. Junkersfeld, A. H. Babcock, James Lyman, Wm. B. Storey, Jr., J. L. Hecht, S. M. Bushnell, J. R. Cravath, F. J. Postel and the Chairman.

The meeting adjourned at 10:05 p. m.

REGULAR MEETING, March 3, 1909.

A regular meeting of the Society (No. 656) was held Wednesday evening, March 3rd. The meeting was called to order at 8:20 p. m. with Second Vice-President Chamberlain in the chair and about 150 members and guests present.

The minutes of the meetings of February 3rd and 17th were read and approved.

The Secretary reported from the Board of Direction the election into membership of the following:

	<i>Grade.</i>
Arthur M. Houser, Chicago	Active
W. L. Thompson, Panama	Active
George Young Skeels, Sioux City, Iowa.....	Active
Frederic H. P. Howard, Ravinia, Ill.....	transferred from Junior to Associate
H. J. Hoodwin, Chicago	Junior
Howard Logan, Chicago	Active
H. B. Sauerman, Chicago.....	transferred from Junior to Active
Alexander R. Webb, Chicago	Junior
Daniel B. Luten, Indianapolis, Ind.....	Active
J. M. S. Waring, Chicago.....	Active

Also that applications for membership had been received from the following:

Fred Coe Taylor, Chicago.
Henry P. Broughton, Madison, Wis.
Gordon F. Dodge, Chicago.
Fred B. Money, Chicago.
Robert I. Randolph, Chicago, transfer.
Frederick W. Adgate, Chicago.
Charles S. Pillsbury, Chicago.
Ward O. Collins, Chicago.
Wm. T. Sullivan, Chicago.

Announcement was made of the death on January 23rd of George Adgate, and on February 22nd of Thomas T. Johnston, a Past President of the So-

ciety. A motion was offered and carried that the President appoint committees to prepare memorials of these gentlemen.

There being no further business to bring before the Society, the Chairman introduced J. H. Prior, M.W.S.E., who read his paper on "Derrick Cars and Bridge Erection, with Some Tests of Iron Pulley Blocks." The paper had been printed in "advance" form and a few lantern slides were used in illustration.

Discussion followed from G. W. Smith (by letter) F. J. Herlihy, I. F. Stern, C. F. Loweth, E. N. Layfield, W. E. Symons, F. R. Judd, O. E. Strehlow and the Chairman.

The meeting adjourned at 10:15 p. m.

ELECTRICAL SECTION, March 19, 1909.

An extra meeting of the Society (No. 657), being a joint meeting of the Electrical Section (No. 41) and of the Chicago Branch of the American Institute of Electrical Engineers, was held Friday evening, March 19, 1909.

The meeting was called to order about 8:20 p. m. by Past-President W. L. Abbott, on behalf of the A. I. E. E., and of the Electrical Section, as Chairman Jackson was out of the city. There were over 100 members and guests present. There was no business to bring before the meeting, so the Chairman introduced Prof. E. E. Creighton, of the General Electric Co., who gave a discussion and "Demonstration of Lightning Phenomena."

By means of a spark coil, the 110 volt lighting current was raised to 40,000 and perhaps 80,000 volts, and caused to discharge between wires stretched about the room. The theories of the origins of electrical charges in the clouds and the discharge of the same, was explained by Prof. Creighton, also abnormal potentials resulting from surges caused by line disturbances. This was followed by a description of various types of lightning arresters, including the aluminum cell, and the effect of each of these devices under various conditions, when used to protect distributing systems and generating apparatus.

Some discussion with questions, followed from Messrs. W. J. Warder, James Lyman, F. Lubberger, E. McCullough, the Chairman, and others.

The meeting adjourned soon after 10 p. m.

EXTRA MEETING, March 24, 1909.

An extra meeting of the Society (No. 658) was held Wednesday evening, March 24th. The meeting was called to order about 8:30 p. m., with President Allen in the chair and about one-hundred members and guests present.

The President said that this occasion was almost the fortieth anniversary of the organization of the Society, and that REMINISCENCES would be the order of the evening.

Mr. L. P. Morehouse, the first Secretary, told of many interesting matters pertaining to the early history of the Society, and gave reminiscences of the members of those days.

Mr. C. H. Hudson, whose recollections of the Society went back to 1876, spoke of the encouraging growth in numbers, and called attention to the changes that have occurred in engineering practice during the last thirty to forty years, with the development of specialists. He also stated that in the early days a civil engineer was called upon for advice and assistance on a great variety of subjects, and it speaks well for the genius of some of the men of those days that they could respond to the call and do the work required.

Mr. Benezette Williams, a Past President, followed Mr. Hudson, and after his remarks on the early membership of the Society, the Secretary read letters which had been received from Messrs. R. P. Morgan, T. J. Nicholl, Walter Katte, A. W. Paige, A. W. Wright, J. W. Weston, and J. S. Sewall.

The meeting adjourned about 10 p. m., when refreshments were served and the meeting became a social one.

REGULAR MEETING, April 7, 1909.

A regular meeting of the Society (No. 659) was held Wednesday even-

ing, April 7th. The meeting was called to order at 8:25 p. m. with President Allen in the chair, and about 60 members and guests present.

The minutes of the meetings of March 3rd and 24th were read and approved.

The Secretary reported from the Board of Direction that at their last meeting eleven new members were elected and one transferred from Junior to Active grade, as follows:

	<i>Grade.</i>
Frederick W. Huels, Madison, Wis.....	Active
Frank Griffith Todd, Chicago	Junior
Paul E. Green, Chicago	Active
Fred Coe Taylor, Chicago	Junior
Henry P. Broughton, Madison, Wis.....	Active
Gordon F. Dodge, Chicago	Active
Fred B. Money, Chicago	Junior
Robert I. Randolph, Chicago.....	transferred from Junior to Active
Frederick W. Adgate, Chicago	Active
C. S. Pillsbury, Chicago	Junior
Ward O. Collins, Chicago	Active
William T. Sullivan, Chicago	Junior

Also that application for membership had been received from the following:

Edward Zaremba, Chicago	Active
Horace B. McCabe, Chicago	Active
Thomas W. Orbison, Appleton, Wis.....	Active
Hugh McLennan, Chicago	Active
James O. Heyworth, Chicago	Active
Hiram W. Elliott, Chicago	Junior
W. H. Kellogg, Jr., Grand Rapids, Mich.....	Junior
Joseph D. McCord, Milwaukee, Wis.....	Junior
Charles Stewart, Chicago	Junior

The Secretary stated that the Committee on Amendments had been asked by the Board of Direction to consider what, if any, amendments to the By-Laws, in their opinion, should be made, and to report to the Board at their next meeting. Also that the Board desires that members of the Society who may have suggestions to make, concerning amending the By-Laws, give these to the committee in the immediate future.

Announcement was made of the death of Mr. J. W. Schaub, M.W.S.E., March 30th, 1909, and of Mr. H. J. Ott, Jun. M.W.S.E., September 25th, 1908. On motion of Mr. Layfield, the President was authorized to appoint committees to prepare memorials of these deceased members.

Mr. A. Bement, M.W.S.E., was then introduced, who presented, in abstract, his paper on "The Coal Fields of Illinois." Discussion followed from W. L. Abbott, Gordon Buchanan, J. K. Dering, Paul P. Bird, F. W. DeWolfe, C. W. Naylor, Warren R. Roberts, and President Allen. Written discussion was read, which had been received from Geo. S. Rice, Chas. A. Lind, S. W. Parr, E. H. Taylor, and W. T. Ray, with a closure by the author.

Mr. Bement offered a resolution, which was duly seconded and carried, that a committee be appointed to draft a memorial for presentation to the State Legislature, petitioning for the establishment of a Department of Mines at the State University of Illinois.

The meeting adjourned at 10:50 p. m.

ELECTRICAL SECTION, April 16, 1909.

A joint meeting of the Electrical Section, W. S. E. (No. 42), and of the American Institute of Electrical Engineers, being meeting No. 660 of the Western Society of Engineers, was held Friday evening, April 16th. The meeting was called to order at 8:20 p. m. by Chairman, Wm. B. Jackson, with about 230 members and guests present. The minutes of the joint meetings of March 2nd and 19th were read and approved.

April, 1909

There being no other business, Mr. B. R. Shover, of Gary, Indiana, was introduced, who gave an interesting talk, with many lantern slide illustrations descriptive of "The Electrical Equipment of the Gary Steel Plant." Some discussion followed from Messrs. James Lyman, J. M. S. Waring, C. T. Henderson, and others.

Chairman Abbott of the A. I. E. E. announced that an invitation had been received to visit the Gary plant on the 24th of April, and this invitation was accepted.

The meeting adjourned about 10:30 p. m.

EXTRA MEETING, April 21, 1909.

An extra meeting of the Society (No. 661) was held Wednesday evening, April 21st. The meeting was called to order at 8:30 p. m., with Vice-President Chamberlain in the chair and about 50 members and guests present. There was no business before the Society, but the Secretary announced that there would be an excursion to Gary, Indiana, to visit the Steel Works on Saturday, April 24th.

The Chairman then introduced Mr. R. S. Perry, of Philadelphia, who presented his paper on "Protective Coatings for Structural Material." The mode of separation of a pigment from a mixed paint, for the purpose of study, was demonstrated, and the method of testing a pigment was shown.

Discussion followed from Messrs. G. M. Davidson, E. N. Layfield, C. K. Mohler, E. McCullough, J. H. Warder, W. H. Finley, F. H. Bainbridge, O. P. Chamberlain, Houston Lowe, Mr. Perry and his assistant, Mr. H. A. Gardner.

On motion of Mr. Finley a vote of thanks was tendered Mr. Perry for his valuable, instructive and interesting paper.

The meeting adjourned about 10:45 p. m.

J. H. WARDER,
Secretary.

BOOK REVIEWS

DESIGN OF HIGHWAY BRIDGES AND THE CALCULATIONS OF STRESSES IN BRIDGE TRUSSES. By Milo S. Ketchum, Civil Engineer. M. Am. Soc. C. E., M. Am. Soc. Test. Mat., M. Soc. for Promotion of Eng. Education. Engineering News Pub. Co., New York. First edition. Cloth, 6 by 9 in.; pp. 540 xiv; 77 tables; 300 Illustrations in the text and 8 folding plates. Price, \$4.00 net.

This book, as the author explains in the introduction, is supplementary to his "Design of Steel Mill Buildings" but contains sufficient repetition to render it practically self contained, the substance of the two books being practically the first course in bridge design as given in the author's classes.

Part One does not, except in the first few chapters in which the various types of bridges are described and classified and loading and weights are tabulated, refer especially to highway bridges, but is general in its nature and treats the calculation of stresses in a very thorough manner both analytically and graphically. The text is illustrated by a great many classified examples with diagrams and explanations which seem to be unusually clear and well suited for class-room work.

The "influence line" method of calculating stresses and determining criteria for maximum stresses is excellently though very briefly given, and the author hardly seems to realize the importance of this method and the wide use that is actually made of it in calculating draw-bridges and complicated structures with odd arrangements of beams, stringers, or columns. The "influence line" method is of such wide application, so simple and so illuminating as regards conditions of loading and stress that it seems to the writer it should receive greater emphasis in a book of this character. The author also gives the "unit re-action method" for calculating curved chord bridges by a combination of

graphical and analytical methods. The writer has found this method very useful in his own work but regrets that the author does not show the student how to take care of the load, if any, ahead of the section where stresses are being determined or even to call his attention to the very frequent occurrence of this problem.

The highway bridge specifications of C. C. Schneider, Theodore Cooper, the Osborn Engineering Company, and the American Bridge Co., also the specifications of the American Railway Engineering and Maintenance of Way Association, are freely quoted and compared, but the student is left to draw his own conclusions between them. Such comparisons are of great value to the designing Bridge Engineer but the writer feels that, when published without comment in a book like this, they are more apt to confuse than to instruct the student. It would seem to the writer that the specifications of the author (which unfortunately seem to be only a compilation, with the same ambiguities and the same contradictions met with in most of the published specifications) should have been placed in the body of the book and the other specifications referred to in the appendix. The writer also feels that a considerable part of the value of the first part of the book is lost by an over amount of classification and subdivision. The different variations of trusses are treated as though they were separate and distinct things to be analyzed on different principles. It seems to the writer that the general principles should be taught so clearly that the student would be able to make his own applications to various types of trusses which should, of course, be enumerated but hardly given the importance of the space that they occupy in this book.

The second part deals minutely with the design of highway bridges both sub and super-structure, including arches, culverts and reinforced concrete structures of different kinds. There is also a chapter on erection with estimates of weight and cost and one on the general principles of design which covers the problem of determining an economical crossing under given conditions. The cost data are interesting and about as accurate as can be expected in treating a subject that cannot be arbitrarily classified, and where no two people would agree absolutely on the data. The author, however, does not appear to include in his cost estimates the field superintendence and proportionate general expense of organization, neither does he include insurance, although he mentions most of these items under miscellaneous costs. These items, in any scientific consideration of the matter, should be charged to cost and not against profit, and this book would serve a very good purpose if it had given proper emphasis to this fact.

The chapter on the "economic bridge" is excellent, although the opening statement that the cost of the superstructure should equal the cost of the substructure is really worth very little in practice. The abutments are in most instances a fixed quantity as is also the floor or paving, railing and even a portion of the steel work, so that a young engineer is very apt to be led astray by the general rule given by the author. His comparisons given on page 492, illustrate the proper method although he might as well have left out the lumber so as to emphasize the fact that the constant elements do not affect the economy of the crossing.

The second part is copiously illustrated with detail plans of bridges and details of bridges from many sources, covering almost every conceivable variation in design. Some of these designs are bad and some are good, but they are usually put in without special comment. It seems to the writer that an author or publisher takes a very grave responsibility in publishing designs indiscriminately and without proper warnings in display type under the bad features. Illustrations and examples of bad design are of great value when their bad features are accurately pointed out and criticised in the text. There is so much that is bad in the designs shown, that their publication without detailed criticism leads one to believe that they bear the stamp of the author's approval.

In his preface the author complains that the designing of highway bridges has been largely left "to an engineer without experience or the agent of some

Bridge Company who is more interested in the resulting profits than in obtaining a good design."

Unfortunately, although the author's complaint of poor designs is amply borne out by his illustrations, the very worst example of all is a plan of a bridge designed for Boulder County, Colo., shown in plate 166, which has an end post having a ratio of length to least radius of gyration (transversely, which is the direction of bending from wind) of 170 and a compression diagonal 22 ft. long supported in the middle *in one direction only* and consisting of $2-2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$ in. angles *back to back*. Further comment on this design is unnecessary. The writer would like to add that some of the other designs are excellent and many of the best instances are standard plans of some of the Bridge Companies. The writer cannot but feel that the publication of such matter as this, works incalculable harm to the art of bridge designing for we find authority for almost any of the sins of omission or commission in the highway designing of the past. It is easy to say that these examples are taken simply as illustrating present day practice, but this book is going out into thousands of irresponsible hands and it is "not as I say but as I do" that counts. In the writer's opinion, the illustrations of such a book should be taken only from the very best designs and some attempt made to create a standard of excellence to which we may live up to in time.

This part of the book is supplied with numerous tables showing standard weights of bridges, values of moments, shears, etc., shop standards of all kinds, dimensions, weights, saving, etc., for angles, channels and beams, lateral connections, etc. These tables are most useful and necessary both for the student and the designer, but in the writer's opinion most of these tables have absolutely no place in the text of such a book. They should be reserved for an appendix, and, if possible, arranged so that they can be detached in working form.

The chapter on foundations is good, but neither specific nor of very great breadth. Empirical rules are given without discussion of the failures which may result from their strict application. When one reflects that, after all, the substructure is often the more expensive and quite as important a part of a bridge as the superstructure it would seem that something more than the compilation of descriptions and illustrations of a few existing structures might be put in a book which evidently attempts to cover the ground.

In the chapter on reinforced concrete, page 365, the statement that "little is to be gained by the use of steel with a high elastic limit" is naive, to say the least. In this chapter, in so far as the author confines himself to the work of Professors Talbot, Turneaure and Maurer, nothing could be better, but statements such as the foregoing, together with the one about deformed bars in the same paragraph make it necessary for the reader to be very wary of accepting the author's statements regarding a construction with which he is evidently not closely acquainted.

Part Three is very good but open to the same objections of extreme amount of classification and subdivision to which the writer has called attention under the heading of Part One.

The faults in this work are not, in general, basic but may largely be obviated by careful revision, rearrangement and considerable pruning, while there is much that is admirable which ought to be enlarged upon, elucidated and explained by the author.

C. H. C. and A. A.

ARTIFICIAL WATERWAYS AND COMMERCIAL DEVELOPMENT (with a history of the Erie Canal). By A. Barton Hepburn, author of "The Contest for Sound Money." New York. The Macmillan Company. 1908. 5 by $7\frac{1}{2}$ ins.; 115 pages. Cloth, price, \$1.00.

This apparently small volume is a weighty contribution to the literature of that present very live topic, our waterways. The first 15 pages are a historical summary of The World's Canals, which is a fitting introduction to the canal system of New York, considered under the heads of the period

of inception, of development, the present conditions, and the competition against New York City. This last is valuable as showing what the railroad companies are doing, resulting in advantages to other seaports than New York, and just now particularly, what Canada is doing by her system of waterways for a low freight rate on grain from the Northwest to Liverpool. The result of these factors has been a notable falling off of the business of New York. This can be greatly remedied by the enlargement of the Erie Canal, which is now in progress.

The next chapter of the book takes up the Panama Canal,—the progress of the work, its magnitude, etc., is partly indicated. "This great enterprise when finished is destined to prove to the commercial world the most valuable of such works yet undertaken." The author shows at some detail the benefits to commerce of the Isthmian water route and the other routes now in use, the shortening in distance between Western Europe ports as also the U. S. Atlantic ports with South America and trans-Pacific ports in general.

The Waterways Question and Conservation of our Resources is the topic for the last chapter and is worthy of careful consideration. Some valuable matter is gathered in the appendix with tables as to canals of New York, extent, terminals, etc., the Erie Canal dimensions, capacity, etc. Also revenue and expense of sundry New York Canals and many other valuable exhibits. Also some tables of collateral statistics relating to the commerce of New York. Grain and flour movement, growth of New York state, etc., and other interesting tables. An index completes this valuable little book. W.

EARTH SLOPES, RETAINING WALLS, AND DAMS. By Charles Prelini, Professor of Civil Engineering, Manhattan College, New York City,—D. Van Nostrand, N. Y., 1908. ix + 129 pages, with 75 diagrammatic illustrations through the text. 6½ by 9 ins., cloth. Price, \$2.00.

This is a work of five chapters, the author using largely graphical methods for solving the problems pertaining to earth slopes, lateral pressure of earth against a wall, of water against a dam and the design of such structures.

The first chapter is on the stability of earth slopes and treats of the weight of, internal friction of and cohesion in soil—those forces which act on and determine the slope of various materials. The graphical demonstrations and their practical application in determining the slope of equal stability are clear and interesting. The author calls attention to the economy of so designing slopes of large cuts and embankments that at every point the material will have the same tendency to remain in repose, instead of using an arbitrary rule such as a slope of 1 on 1 in common earth cuts.

Chapter two, is on retaining walls. The various theories of earth pressure as advanced by Vauban, Coulomb and others are discussed, followed by Professor Rebhann's method of graphical solution based on the principal of the sliding prism.

Chapter three, takes up Professor Rebhann's analytical method of calculating earth pressure with a discussion of the theories of Rankine and Weyrauch. Tables are given showing the earth pressure against a wall of different heights; three wall sections are used with three conditions of surcharge for each section. The results obtained by the graphical method of Rebhann's and the analytical methods of Rankine and Weyrauch are in this way given a careful comparison.

Chapter four, is on the design of retaining walls. The author illustrates and discusses different types of walls as designed by German, French and English engineers; he then demonstrates graphically the proper width of base for a number of retaining walls of different forms and under varying conditions, followed by an analytical discussion.

Chapter five, is devoted to dams. This subject is treated as a particular case of retaining walls in which the material to be supported is without friction. The author takes up and analyzes the forces to be resisted and then develops a theoretical dam profile. The practical sections as developed by Crugnola and Krantz are illustrated and discussed, the chapter closing with a practical section developed by the author.

The work is replete with diagrams and figures to illustrate the text; every page having a figure corresponding to the analysis so that there is no looking back in order to follow the discussion. Graphical demonstrations are given preference throughout the work, although analytical discussions are given also for comparison. The work is a text book for students and as such its simplicity and clearness are to be highly recommended. Practicing engineers will also find much in it of interest. The mechanical features of the work are good. The type face is clear and the figures and lettering are excellent.

G. H. H.

PRACTICAL SHEET AND PLATE METAL WORK. For the use of boiler makers, *** copper smiths, *** sheet metal workers, *** and others who require a knowledge of *** the working up of metals or the development of surfaces. By Evan A. Atkins. Whittaker & Co., London, and Macmillan & Co., New York. 1908. 5 by 7¼ ins.; 492 pages including index. Over 400 illustrations. Cloth, price, \$2.00.

This English book is designed for the use of the artisan working in sheet metals and the rules for the laying out of the work are based on the supposition of ignorance of descriptive geometry, the lines of intersection and the development of surfaces, for the intersection of cylinders, cones, spheres and the like. The "layout" of such jobs as elbows and joints of pipes, whether cylindrical or square cornered, is simply given,—too much so for one at all conversant with the problems in descriptive geometry given in the lower courses of the engineering schools. Yet to the mechanic engaged in sheet metal work and somewhat familiar with the use of the ordinary tools employed in such work, this book would be of great assistance. Very good instructions by the aid of many diagrams show how to "lay out" the patterns to which the plate metal is shaped so that when these are rolled or otherwise worked up and put together, they will fit and result in giving the proper shape to the desired object.

Instructions are also given for the necessary margins and allowances for the joining together of the several parts, and all of this is done in a very simple and practical way without calling on descriptive geometry, *as such*. The very numerous figures illustrate a great variety of objects, many of which are in frequent use, yet there are others seldom employed, but the instructions with the diagrams are so clearly given that almost any intelligent workman in sheet metal can do the job.

A study of the book is valuable to the draughtsman and the engineer, even if well instructed in theoretical descriptive geometry, as it will show what is practical in the creation of (apparent) solids by the development of the surfaces of the same, where these had best be joined, and how they can best be formed and put together.

Altogether the book has considerable value to the artisan and apprentice draughtsman, and contains much of interest to the engineer. W.

HYDRAULIC TABLES: The Elements of Gagings and the Friction of Water . . . Flowing in Pipes, Aqueducts, Sewers, etc., . . . and the flow over Wiers with quantity discharged. Gardner S. Williams and Allen Hazen, Mems. Am. Soc. C. E. New York, 1909, John Wiley & Sons. 6 by 9 ins., 104 pages, cloth. Second edition, revised and enlarged. Price, \$1.50.

The authors have presented an exponential formula, a modification of the well known Chezy formula, for determining the velocity of flow of water in conduits. By means of a special slide rule based on the authors' formula, which was evolved from the study of a vast number of experiments, the tables in the book show the flow of water in pipes and other passages.

The first table gives the range of value, and the mean value, of the constant c of the Chezy formula, at various velocities for various pipes as; cast iron, new, clean and tuberculated; of riveted pipe, wood stave pipe, cement pipe, circular brick tunnels, etc., etc. This table would be of interest to students

and also of value to engineers, as giving at a glance an approximate value of c which can be used when not too elaborate results are wanted.

The second table is similar, giving the value of c by the Hazen and Williams formula for open channels of various kinds, based on the experiments of Darcy and Bazin, Fteley and Stearns, Horton, Cunningham and others. These values have been computed by means of the authors' special slide rule and by which results can be had for a far greater range of variables than it would be practicable to show in tabular form. There are other tables showing the application of the W. & H. formula and results obtained for a variety of other pipes, as of brass, iron, etc., but exhibiting more especially the loss of head in feet per 1000 feet in length. These tables are carried up to the size of 144 in. in diameter.

An interesting table to municipal engineers on sewer work, is one giving the slopes, in feet per 1,000 feet, required to produce a definite velocity of flow (from 2 to 10 feet) in sewers of sizes ranging from 4 in. to 30 in. of tile, and 2.5 ft. to 20 ft. in diameter, of brick. As a sequence to this, are five pages of tables for tile and brick sewers from 4 in. to 15 ft. in diameter, showing the discharge in cubic feet per second, running full and at various slopes.

In the latter part of the book are 28 pages giving the computed discharge per foot of length over sharp crested vertical wiers, without end contraction, based on the rather complicated formula of Bazin. The hydraulic engineer, in many cases, could use this table direct from his specific observations and thus get results without using the Bazin formula. Following this are a series of tables giving factors for obtaining the discharge over wiers, other than the customary vertical one with a sharp edge, as those with broad or rounded or compound crests, etc.

The book should be of much value to engineers engaged in sanitary work or hydraulic power development, as the tables cover such a range of conditions that desired results can be obtained with a minimum of mathematical computation. W.

THE THEORY AND PRACTICE OF BRIDGE CONSTRUCTION. By Morgan W. Davies, Assoc. M. Inst. C. E., etc. Cloth, $7\frac{1}{2} \times 5$ ins; 594 pages with over 500 illustrations. Price \$3.75. The Macmillan Company, New York, 1908.

This interesting text book begins with the subject of beams. All the ordinary cases of loading are discussed, each case having diagrams illustrating the loading, moments, and shears, while the text gives the methods of finding the same at any place in the beam and for some particular example. The treatment accorded to many different kinds of trusses, is similar. The diagram of the truss is shown and diagrams showing maximum chord stresses and web stresses are given, and also an example is completely worked out under each type of truss shown. A few examples of cantilever bridges are similarly discussed.

There is a discussion of the permissible stress on wooden, iron and steel beams and columns and the methods of determining the strength of such. Also on the strength of riveted and pin joints, on deflection and on the continuous girder. Arches are treated in an extended discussion with plenty of illustrations and actual examples worked out. Suspension bridges are briefly discussed. Bridges which open and which included many special types are treated in a very competent manner. The book is closed with two chapters on bridge details. The author is to be commended for the omission of Greek letters and formula; second, for the use of special examples, and third for the abundance of illustrations. The book should be of value to students in the art of bridge design, as well as to practicing engineers. J. G.

THE ELEMENTS OF PHYSICS. A College Text-book. By Edward L. Nichols and William S. Franklin. In Three Volumes. Vol. II. Electricity and Magnetism. New edition; entirely rewritten. The Macmillan Co., New York, 1907. Cloth, $5\frac{1}{2}$ by $8\frac{1}{2}$ inches; pp. 303. Price \$1.60.

This book fulfills all the requirements of a college text-book for a general

course in Electricity and Magnetism. It contains all the essentials and omits all the non-essentials of the subject. One of the most striking characteristics of the book is the fact that the arrangement of the sub-divisions of the subject is entirely different from that of most similar works.

The first chapter deals with Magnetism, explaining the magnetic field as a state of ether stress and magnetism as a molecular phenomenon. The second chapter takes up the Electric Current, explaining its effects, magnetic, chemical, heating, etc., and introduces the various current measuring devices. The next chapter deals with Electromotive Force, Resistance, and Joule's law. Then follow in the order given, chapters on Induced Electromotive Force, explaining the dynamo, induction coil, and transformer; Electrolysis with the dissociation theory and a description of the various forms of voltaic cells; Electrical Measurements including measurements of current, resistance, electromotive force, power, and magnetic fields; Inductance, self and mutual; Magnetism of Iron, giving the theory and methods of testing; Thermo-electric Currents; three chapters on electro-statics covering the condenser, the electric field, influence electric machines, and electrometers; the Phenomena of Electric Discharge, including convective and disruptive discharges, the electric arc, cathode and Roentgen rays, ionization of gases, Hertz's experiments, electric waves, and wireless telegraphy.

Chapter XIV takes up Some Practical Applications of Electricity and Magnetism and contains an explanation of the Morse telegraph, diplex telegraphy, duplex telegraphy, quadruplex telegraphy, synchronous multiplex telegraphy, printing telegraphy, telautograph, submarine telegraphy, the telephone, electric lighting, electric furnace, electrolytic interrupter, and electric welding. Chapters XV, XVI, and XVII deal with Mechanical Conceptions of Electricity and Magnetism, the Electromagnetic Theory of Light and Distributed Quantity explaining the various geometrical notions which arise in the study of electricity and magnetism. The book is concluded with a list of 145 representative problems covering the whole subject. The work should appeal especially to instructors having in charge a course in college physics. F. A. R.

THE DESIGN AND EQUIPMENT OF SMALL CHEMICAL LABORATORIES. Richard K. Meade, B. S., Editor of the Chemical Engineer. The Chemical Engineer Publishing Co., Chicago. Cloth; 6 by 9 in.; 136 pages with 111 illustrations. Price \$2.00, postpaid.

To the chemist who has not had the opportunity of traveling over the country and visiting many of the laboratories in existence, this work will undoubtedly prove of material benefit as a guidance in the proper arrangement and equipment of a chemical laboratory. It is appreciated that the laying out and equipment is dependent very largely upon the class of work which is to be carried on. The matter set forth in this book, however, represents the fundamental principles involved in equipping a laboratory for almost any class of work. It has the advantage of not only being rather profusely illustrated with cuts of apparatus for different purposes, but also gives the names of the manufacturers or dealers in same. This, especially to the young chemist, is, we believe, an advantage.

The illustration on page 34, of "Pump and Receivers for Blast or Suction," seem to be not strictly up-to-date, especially for laboratories located where an electric current can be had, as with the more modern motor driven blower and exhaust fans, or small air compressors, the hand pump and room occupied by storage tanks is eliminated.

Chapter XI on "Apparatus for Electrochemical Analysis" will no doubt prove valuable even to those in charge of some of the older and longer established laboratories, as this method of separation of many of the elements is gaining ground from time to time. W. A. C.

PRACTICAL CALCULATIONS OF TRANSMISSION LINES. By L. W. Rosenthal, E.E., Assoc. M., A. I. E. E. McGraw Publishing Co., New York, 1909. Cloth; 9½ by 6¼ ins.; pp. 93; many tables and formulæ. Price, \$2.00 net.

The author in his preface states that his object has been to provide data and formulas so arranged, that by the substitution of known factors, problems in alternating and direct current transmission and distribution work can be readily solved without the necessity of long and involved calculations. The size of wire is determined directly from the volt loss by substitution of known factors taken from suitable tables.

The above object is accomplished by combining all the items involved by means of tables, and developing formulas which give the results directly.

Chapter No. 1 is devoted entirely to ordinary direct current distribution calculations. Tables are given showing the variation of the conductivity of different conductors at different temperatures, the properties of conductors of different sizes, and other variable factors.

Standard formulas for calculating the heating of conductors, resistance of conductors in parallel, etc., are given, after which the author has given formulas conveniently arranged and including the above variables, so that calculations may be made by direct substitution of known terms.

The second chapter is devoted especially to direct current railway calculations. The tables and formulas are arranged similarly to those in Chapter No. 1, the subject matter being different although the methods are the same. Attention is given to the calculation of the drop along the return, whether by rail, rail reinforced by cropper, double trolley, or conduit.

Chapter No. 3 is devoted to the calculation of alternating current transmission by overhead wires.

The present methods of calculation of alternating current distribution are often tedious and complicated, some items necessitating repeated trial calculations before the final result is secured. These trial methods are not necessarily accurate for all practical conditions. The author describes his method as follows:

"All items which depend on the frequency, size of wire, load power-factor and wire spacing were grouped into the term, which is denoted by the symbol 'M,' and called the wire factor. All other variables that determine the size of wire were grouped into the second member of the equation of 'M.' Then after introducing the proper transmission factors, the equation took the form shown in the table of formulas opposite the size of wire. The remaining formulas are simple derivatives either from the equation of 'M,' or from well known relations."

The author, in support of his method, gives a table showing the variation of the accuracy of the results obtained by the present methods of calculation for different frequencies, power factor and size of wire. In some cases the error is stated to be as high as 200%.

Considerable space is given to a discussion of the different variables and to explanations of his method. Problems are given and worked out in detail, illustrating the application of his method in practical problems. The latter portion of the chapter is devoted to the formulas and tables of the various factors required for substitution.

The next chapter is confined to underground alternating current calculations for determining the size of conductor, drop, heating, etc. The methods are the same as for overhead conductors, although the tables are naturally different. A chapter is devoted to the calculations of interior wiring, giving the necessary formulas, tables etc. The last chapter is devoted to single phase distribution for railways.

The methods of the author, although not new in principle, are novel in their applications. The complicated equations have been eliminated, and their places supplied by simple formulas, whose terms are obtained from groups of table containing the variable quantities.

Many calculations of practical transmission problems have been made by the author's methods, and compared with results from the present methods, and while the same final results are obtained, his methods are accurate and applied with unusual facility.

Throughout the book considerable space is given to discussion of the effects of the different variables, and to explanation in detail of the application of the methods. Many problems are worked out in the different chapters clearly illustrating the application of the formulas. The book should be very desirable to the profession, at least as a means of checking figures, if not for the primary calculations.

E. F. S.

RESERVOIRS FOR IRRIGATION. By James D. Schuyler, M. Am. Soc. C. E., 2nd edition, revised and enlarged. New York, John Wiley & Sons, 1908. Cloth, 573 pages, 6½ by 10¼ ins. with 6 folding plates and 381 illustrations. Price, net, \$6.00.

It is of some interest just now, to know that since this book was issued, the author, Mr. Schuyler, was selected by President Roosevelt as one of a committee of expert engineers to visit the Panama Canal, and give an opinion on that piece of work. This related particularly to the type of canal with locks which is under construction and incidentally upon the stability of the Gatun Dam, about which there have been many conflicting statements in the newspapers. The author has brought out a large volume which is mostly descriptive, with views of various dams (in many cases taken by himself) constructed for the purpose of creating reservoirs of water. These dams cover a wide range of situations, sizes, modes of construction, etc., and the book is of great value to the engineer at all concerned in this class of work. If he has a problem relating to the construction of a reservoir by means of a dam for the improving of a water supply for irrigation purposes, or hydro-electric power development, or a municipal water supply, then a study of the many examples of dams shown in this book, would at least give him some valuable data as to this work, if it would not give an example of design and construction applicable to the piece of work he has in hand.

The title says: for Irrigating, Water Power, etc., and this seems a reasonable order, when it is known that the first draft of the book was written for the U. S. Geological Survey as one of the "Water Supply and Irrigation Papers."

The earlier type of dams for irrigation use and in the mining districts, were of rock fill with perhaps a sheathing of planks, or perhaps an earth covering. The next modification was the use of an earth fill over or above the rock base, by sluicing or hydraulic work. Many dams of this construction have proved very serviceable. The unit of capacity of Irrigation reservoirs, the "Acre-foot," is one that is not so readily comprehended by engineers engaged in hydro-electric work or for municipal water supplies, but is largely used through this book because of the earlier work of the author. There are many descriptions of dams as built, whether in the United States or Canada, Mexico, or elsewhere, with many illustrations from photographs and some from line drawings. The book does not go into any mathematical discussion of stability, or theory of design, but is a description, generally full in detail, of dams that have been built, how built, and the cost of construction in many cases is given. Failures of certain dams, such as that of Austin, Texas and others are also recorded.

The book is an interesting one to read, even by the layman, with its many illustrations, and is a valuable contribution to the literature on this subject.

THE PORTLAND CEMENT INDUSTRY FROM A FINANCIAL STANDPOINT. By Edwin C. Eckel. From *Moody's Magazine*, New York, 1908. Size, 6 by 9 ins. Cloth bound, 93 pages and a two page map of United States showing location of Portland cement plants. Price, \$2.00 net.

The author of this valuable and interesting little book is known to many by his connection with the U. S. Geological Survey, as author of Reports on Production of Portland Cement in various years and different localities. He is also the author of a valuable text book on "Cements, Limes and Plaster," published by Wiley & Sons, New York. This present work may not be

engineering in a strictly technical sense, but is engineering in the higher sense, that it gives sane and conservative advice on the Portland cement industry from the view point from which all projects must sooner or later be considered, "Will it Pay?"

The first chapter is an historical sketch of the manufacture of Portland cement, abroad and in this country, including a reference to the rotary kiln and the improvements in grinding machinery, the two factors which have had the most influence on the growth and development of the cement industry, with the consequent lowering of prices.

The next chapter is more statistical, showing the production of Portland cement, quantity, and value in various states and in districts, and also the imports and exports, with a table of apparent consumption annually and the decline in price since 1880. In 17 years, from 1890 to 1907, the production of Portland cement increased from about 1/3 million barrels to nearly 49 million barrels, or nearly 145 times, but the price per barrel during that time (with some occasional exceptions) has fallen from \$3.00 to below \$1.00 per barrel in 1904. Of course during this time there have been many improvements in the manufacture and a consequent cheapening in the cost of production, yet a knowledge of the true financial conditions of many going concerns would doubtless show them to be unprofitable to their owners, if not absolutely money losers.

This leads naturally to Chapter III, "The Outlook for the Future," in which the "Future Growth," "Possible Decreases in Costs," "Future Course of Prices," "Possible Price Regulation," etc., etc., are valuable and instructive to the general reader. A careful study of this chapter and the next on "The Factors Influencing the Valuation of Cement Securities," and indeed of the whole book, should be made by everyone before investing any money in new cement projects. Space does not permit more detailed reference to the various sub-heads of succeeding chapters, but the author further shows his wide knowledge of the whole subject.

The book is well written and printed in an attractive form. It should be thoroughly read and comprehended by those who are interested in the manufacture of Portland cement, or who are "approached" to take an interest and invest good money in some new and alluring proposition for a Portland cement manufactory.

W.

ENGINEER'S POCKET BOOK OF REINFORCED CONCRETE. By E. Lee Heidenreich, Civil Engineer, M. Am. Soc. Test. Mat., M. Am. Inst. Min. Eng. Myron C. Clark Publishing Co., Chicago. Flexible leather, pocket-book style; 4½ by 6½ ins.; pp. 365; 164 figures in text; LXXXII tables. Price, \$3.00.

In the opinion of the reviewer, this is really a good book and worth the money. It is very elementary in spots but that is a strong point in its favor, for many of the books published are weak on elementary points in connection with reinforced concrete design and the planning of reinforced concrete structures. We have in this book the usual matter to be found in works dealing with structural material relating to construction operations, but it is greatly abridged and collected from new sources, many of the works being those of the author of the book. For one thing he has given in detail the design of a building with all the footing calculations.

There are some very good slab tables and a most complete set of tables for spirally wound columns. There is also a good chapter on arch bridges, and the subject is treated very well, but like the majority of authors who treat on the arch the author forgets that an arch bridge consists of the arch ring and the abutments and he touches only upon the arch ring, omitting any reference to abutments except to assume that they are rigid.

He covers the ground in that he has good chapters on retaining walls, bins and elevators, dams, sewers, conduits, etc. At present it is probably the best American pocket book on reinforced concrete and will be found very useful by many designers.

E. McC.

AIDS TO SHIPPERS. By the Forwarding Department of Oelrichs & Co., Bowling Green Bldg., New York. Boards, 6¾ by 9 ins., 62 pages, 1908.

This valuable hand-book, to those at all interested in our foreign trade, has been prepared by the American representatives of the North German Lloyd Steamship Co. It is indeed an "Aid to a Shipper" besides being a skillfully prepared "solicitor for business" for that great German marine transportation company. The magnitude of this company may be inferred when this book shows fourteen different steamer lines to Germany with stops at Plymouth and Cherbourg; the Mediterranean; the Levant; also Baltimore; Savannah and Galveston to Germany, Australian service from Germany, and to Brazil, the River Platte, Cuba, Japan and the East Indies. It would seem as though there was hardly a port of any consequence throughout the world that could not be reached by the service of the North German Lloyd S. S. Co.

The "Primary Suggestions" are common-sense instructions too often ignored, or forgotten, with consequent delays and increased expenses. These instructions include packing and marking consignments, Weights, Legal, Net and Gross; Drafts, Duties in Foreign Countries, Insurance, Terms of Sale, etc. There are tables of value of foreign coins and currencies and foreign moneys reduced to U. S. equivalents at par, foreign weights and measures with corresponding U. S. equivalents; also metric weights and measures. There are also some seven pages giving express rates from New York to various foreign ports, that are valuable.

The book may be had on application to the publishers.

TRADE CATALOGUES.

HEYWORTH-NEWMAN EXCAVATORS. By James O. Heyworth, Harvester Bldg., Chicago. Oblong, 10 by 6½ ins., 24 pages.

This handsome publication describes, with a dozen fine illustrations of half tone and line engravings, this drag-scraper excavator and the work in which it has been employed. For a variety of situations this machine possesses advantage over the ordinary steam shovel, possessing a long reach, ready action, and convenient dumping arrangements. Some extensive contracts in excavation have been executed by James O. Heyworth & Co., with this machine, with widely varying material, as sand under water at Michigan City, clay at Evanston, glacial drift at Gary, and hard pan at Lake Forest. The publishers are to be commended for issuing such a handsome and instructive catalogue.

JEFFREY RUBBER BELT CONVEYING MACHINERY. Jeffrey Manufacturing Co., Columbus, Ohio. Catalogue 67 D, 6 by 9 ins., 48 pages.

This circular, with a great many fine half tone illustrations, shows applications of rubber belt conveyors as applied to a great variety of situations and of materials, as coal to coal storage bins, ore to and from bins, stone and clay, etc. One installation of interest, locally, is that of the Chicago Post Office for handling the sacks of U. S. mail in the Post Office and at the R. R. Stations. Anyone interested in the problem of handling material, whether conveying or elevating, will find a study of this book both interesting and profitable.

AMERICAN EQUIPMENT Co., Norristown, Pa. The Mitchell Bridge Erecting and R. R. Wrecking Car Catalogue A 2, 1908. Pamphlet, 6¾ by 9¾ ins., 12 pages.

This catalogue is well illustrated with a number of line engravings showing the various parts of the equipment and arranged for various uses in bridge erection or wrecking work. The car proper is built especially for the service demanded; the design and construction of the several parts is excellent; the dismounting of the boom, 50 ft. long, and storing it below the A frame within a pocket provided for the purpose in the car, is a point of considerable advantage when shipping the car from one point to another on the line. The A frame is of very substantial construction and can be folded back on to

the car, thus reducing the head room when in transit. The car is provided with two auxiliary booms, placed at either side of the main boom, to be used in erection work or can be used as stays or anchorages when the main boom is lifting loads from the side of the track. Steam power of ample capacity is provided for the hoisting engine and also for an auxiliary engine which applies power through chain gearing to the forward truck for moving the car, as in carrying forward material to be erected. The speed of this movement is usually 4 miles per hour, but when not carrying a load suspended from the boom, may be increased up to 15 miles per hour. When moving the car a considerable distance the boom is disconnected, the A frame put back on the car, the chain gear from the forward truck is taken off, and the car can be moved any desired distance by locomotive power.

When its destination is reached, by its own steam power the A frame and the boom, or booms, are set up in place, all within a short space of time and the car is ready for its work.

The capacity of the car ranges from 40 tons, at a 25 ft. reach, to 10 tons at a 70 ft. reach, the full length of the boom. The whole design has been most thoroughly worked out by Mr. S. P. Mitchell, the president of the company, who did some notable bridge erection while with the Edge Moor Bridge Co., some years ago.

THE VULCAN IRON WORKS, Chicago. Pile Driving Machinery. Catalogue No. 31, 1909.

This little pamphlet of 60 pages, 5 by 6½ ins., contains a great deal of interesting matter to those engaged in driving piles. Various sizes and weights of pile drivers are shown, which are supplied complete with all wood work; or iron work only can be purchased, with drawings and bill of timber required by which the purchaser can get out the complete machine and save the cost of transporting the wood-work. Considering the length of leaders and other parts of the frame, with the consequent cost of transporting to any distance, it is frequently cheaper for the purchaser to provide himself with the necessary wood-work, at the place where the work is to be done.

The well known Warrington steam pile driver is also described in the book, and its advantages in work, particularly if heavy, and there is much of it, is shown. Prices for the several parts and of the complete machine are not given, but these can be had on application to the Vulcan Iron Works, No. 28 North Irving Ave., or Station "D" Chicago.

MORSE SILENT RUNNING HIGH SPEED CHAINS. The Morse Chain Co., Earl C. Moss, Chicago Manager, room 805, Merchants Loan & Trust Bldg., Chicago. Catalogue No. 7, Pamphlet, 6 by 9 ins., 20 pages.

This is a very neat catalogue of the Morse Chains used in transmitting power in rotating machinery. The sprocket wheels and pinions, on the motor, and the machine, are virtually gear wheels though with the teeth shaped somewhat different from those of the regular spur gears. The chain may be likened to an endless and flexible rack, with teeth of a size, shape and pitch, to properly mesh with the gear wheels or sprockets of the driving and the driven machine. The shaping of the teeth of the sprockets of the gear and pinion is of importance, but of yet more importance is the shaping of the flat steel plate links of the chain, so formed that parts of each link fit into and properly mesh with the sprockets and thus transmit the power by a positive action. Of the highest importance in the Morse Silent Running Chain Drives, is the Morse Rocker Joint pivot which gives the flexibility to the chain. This construction is such that there is not the rubbing action and wear of a cylindrical pin, but the pivot is made of two peculiarly shaped pins of tool steel so fitted in the links of the chain that the flexing of the chain is from a rocking motion between the faces of the compound pin. The friction due to rubbing action (resulting in wear), is a minimum, nor is it necessary to provide lubrication for the pivots with this rocker action. This last feature is a valuable one for with high-speed chains, lubrication is very

difficult to obtain. The device is an admirable one and the book will repay the study of those concerned in the transmission of power.

CAMP-DUCT. The H. B. Camp Co., Manufacturers of Vitrified Salt-glazed Conduit for Electrical Subways, Chicago, Commercial National Bank Building. Pamphlet, 7 by 11 ins., 16 pages, followed with 14 pages of line engravings interleaved with cross-section paper suitable for notes and sketches.

The line illustrations, show various forms, sizes and combinations of ducts for underground work with drawings for construction of manholes, etc. In the text is a table for computing the cost of underground conduits, followed by a typical specification and contract for the construction of such work. There are also some letters of testimony from users of the Camp Duct, showing it had the approval of those who have used it. For those in anyway interested in underground electrical work, the pamphlet should be of interest and use.

REVIEW OF CONCRETE CHIMNEYS. The Weber Co., Chicago. Pamphlet, 6 by 9 ins., 24 pages with 3 H. T. illustrations.

OUR PRIDE. The Weber Co., Marquette Bldg., Chicago. Pamphlet, 5 $\frac{3}{8}$ by 7 $\frac{1}{4}$ ins., 16 pages.

These two pamphlets relate to concrete chimneys as built by the Weber Co. The smaller pamphlet, "Our Pride," is a list of Weber chimneys with sizes, as constructed by this company from their own designs, in 38 different states in the union and also in the District of Columbia. Also others built in the Canadian provinces and in Europe. Such a list is valuable as showing the extensive business of the Weber Co., in chimney construction; also it has a value as a directory of Weber chimneys to aid a possible purchaser to visit the plants where such chimneys have been erected, and learn first-hand, from those making use of the chimneys, whether they are satisfactory or not.

The larger pamphlet is an argument in favor of concrete chimneys in general, and particularly of the Weber construction with its system of reinforcement. There is no doubt but that the Weber Co. have been successful in their work, having built hundreds of such chimneys, some of remarkable magnitude, and one would judge, to the satisfaction of the purchaser. As a review of concrete chimneys, the pamphlet would have much greater value to engineers if it contained more specific and detailed information as to the construction, method of reinforcing, preparation, erection and removal of forms, the handling of concrete, etc. But it is probably asking too much to look for such valuable engineering data to be published and distributed gratis, when it is a valuable part of their business.

LIBRARY NOTES.

The Library Committee wishes to express thanks for donations to the library. Back numbers of periodicals are desirable for the change and in completing valuable volumes for our files.

Since the issue of the JOURNAL for February, 1909, we have the pleasure to report the following additions to the library and gifts from donors named:

MISCELLANEOUS GIFTS.

- E. E. R. Tratman, M.W.S.E., Bulletin International Railway Congress, Jan. 1909. Pam.
Report of General Manager of Railways, Cape of Good Hope, 1907. Pam.
University of Illinois, Bulletins Nos. 1, 4, 28.
Illinois State Geological Survey, Bulletin No. 8. Cloth.
Water Supply and Irrigation Papers, Nos. 217, 220, 221, 222, 225, 226.
Proceedings American Society of Civil Engineers, Feb. and March, 1909. 2 pams.
Illinois Waterway Report, 1909. Pam.
Proceedings 18th Annual Convention American Railway B. & B. Assn. Pam.
Wisconsin Survey Bulletin No. 20, Water Powers of Wisconsin. Cloth.
Transportation by Water, Census Office Cloth.
Etude sur L'Aviation. Pam.
Journal, Railway Signal Association, Feb., 1909. Pam.
Progress Report, Joint Commission of Concrete and Reinforced Concrete Commission. 2 pams.
Joint Meeting of Mathematicians and Engineers. Pam.
Proceedings Association of Transportation and Car Accounting Officers, Dec., 1908. Pam.
Public Health, Michigan, Jan.-Mar., 1909.
General Map of Relocated and Present Operated Lines of Panama Ry.
Dwight C. Morgan, M.W.S.E., Minneapolis, Supplement to Annual Report of R. R. & Warehouse Commission of Minn.
Report of Dwight C. Morgan, Engr., To R. R. & Warehouse Comm. of Minn.
M. C. Clark Publishing Co., Chicago, Engineers' Pocketbook of Reinforced Concrete, Heidenreich. Leather.
Engineering Work in Towns and Cities, McCullough. Cloth.
W. Plenkner, Vienna, Austria, A Study of the Damming Effect of Bridge Piers upon Streams. Pam.
Department of Mines, Western Australia, Report on the Northampton Mineral Field. Pam.
Report on the Kanowna Mines. Pam.
Report on the Mines of the Yilgarn Goldfield.
A. O. Cunningham, St. Louis, Engine Terminal Facilities Constructed by the Wabash R. R. at Decatur, Ill. Pam.
James E. Wonders, Columbus, Ohio, 4th Annual Report of State Highway Department of Ohio. Pam.
Board of R. R. Commissioners of Mass., 40th Annual Report, 1908. Cloth.
New Jersey Sanitary Association, Proceedings of 34th Annual Meeting. Pam.
Boston Transit Commission, 14th Annual Report of Commission, 1908. Cloth.

- The Technology Club, Syracuse, N. Y., Industrial Engineering and Organization Trump. Pam.
- American Railway Bridge and Building Association, Proceedings of 18th Annual Convention, 1908. Pam.
- Iowa State Geological Survey, Annual Report, 1907. Cloth.
- McGraw Publishing Co., New York, Law and Business of Engineering and Contracting. Fowler. Cloth.
- Transmission Calculations. Rosenthal. Cloth.
- Heat, Energy and Fuels. Jüptner. Cloth.
- Dr. Edward Bartow, Director, University of Illinois, State Water Survey Bulletin No. 6. Cloth.
- Chemical Engineer Publishing Co., Chicago, The Design and Equipment of Small Chemical Laboratories. Mead. Cloth.
- Geological Survey of Michigan, Vols. 5, 6, 7, 8, 9 of Survey. 7 books, cloth.
- Annual Reports 1903-4-5-6. 4 pams.
- American Society of H. & V. Engineers, Transactions, 1907. Cloth.
- Wagner Free Institute of Science, Philadelphia, Transactions, Vols. 1-6 incl.
- Drexel Institute, Philadelphia, Year Book, 1908-09. Paper.
- Maj. T. H. Rees, M.W.S.E., Topographical Surveying and Sketching. Rees.
- Dwight C. Morgan, M.W.S.E., Reports of R. R. & Warehouse Commission, Minn., 1905-6-7. 3 books, cloth.
- Thomas W. Jaycox, Denver, Colo., 14th Biennial Report of State Engineer of Colo. 2 pams.
- Commissioner of Public Works, Trenton, N. J., Report of Commissioner of Public Works for 1908. Cloth.
- Commissioner of Highways, Augusta, Me., Report of Commissioner for 1908.
- Dr. Oskar Nagel, New York, The Mechanical Appliances of the Chemical and Metallurgical Industries. Nagal. 1908. Cloth.
- Dr. C. O. Probst, Columbus, Ohio, Water and Sewage Purification in Ohio, 1908. Cloth.
- National Association of Cotton Manufacturers, Boston, Transactions, Semi-annual Meeting, 1908. Bds.
- Paul D. Sargent, Augusta, Me., 1st, 2nd, and 3rd Annual Reports of Commissioner of Highways, State of Maine. 3 vols., cloth.
- The Macmillan Co., New York, Applied Mechanics for Engineers. Hancock.
- A. Gibb Maitland, Perth, W. A., Geological Survey, Western Australia, Bulletins 31 and 34. 2 pams.
- Canadian Society of Civil Engineering, Montreal, Report of Annual Meeting, 1909. Pam.
- List of Members, 1909. Pam.
- Internal Improvement Commission of Illinois, Illinois Waterway Report. Pam.
- Wm. H. Scoville, New Haven, Conn., Report of Bureau of Labor of Connecticut, 1908. Cloth.
- Prof. L. P. Breckenridge, M.W.S.E., Bulletins, University of Illinois, 18-26 incl. 1907-08. Bound vol.
- American Gas Institute, N Y., Transactions, 1908. Cloth.
- American Mining Congress, Denver, Proceedings of 11th Annual Session, 1908.
- Samuel M. Rowe, M.W.S.E., Preservation of Timber. Rowe. Leather.
- Dr. C. O. Probst, Columbus, Ohio, 22nd Annual Report of State Board of Health of Ohio, 1907. Cloth.
- Manchester Institute of Arts and Sciences, Manchester, N. H., Proceedings, 1909. Pam.
- Water Board, Lawrence, Mass., Annual Report, 1907. Pam.
- Advisory Board of Consulting Engineers, N. Y., Report to Governor Relating to work on Barge Canal, 1907-08. Pam.
- J. H. Warder, Secretary, Report of Naval Advisory Board on the Mild Steel used in the "Dolphin," "Atlanta," "Boston," and "Chicago" U. S. Navy Dept. 1886. Cloth.
- American Sanitary Engineering, Philbrick. Cloth.
- Elements of the Differential and Integral Calculus, Church.

- Papers on Hydraulic Cements and Concretes, etc. Leather.
 Elementary Treatise on Natural Philosophy. Deschnel. Cloth.
 Manual of Qualitative Chemical Analysis. Fresenius. Cloth.
 The Corporator's Manual. Binmore. Leather.
 Elements of Surveying and Navigating. Davies. Leather.
 Pocketbook of Mechanics and Engineering. Nystrom. Leather.
 Manual of the Mechanics of Engineering. Weisbach. Cloth.
 Treatise on Gems. Feuchtwanger. Cloth.
 Manual of the Mechanics of Hydraulic Engineering. Weisbach. Cloth.
 Lay Sermons, Addresses and Reviews. Huxley. Cloth.
 Great Facts: Remarkable Inventions in the 19th Century. Bakewell. Cloth.
 Cyclopedia of American Horticulture. Bailey. 4 vols. Cloth.
 The North American Sylva. Michaux and Nuttall. 6 vols. American Woods. Hough. 3 vols. Cloth.
 Ohio Geological Survey, Zoology and Botany. 1882. Cloth.
 Sec'y of War: Report for a R. R. Route from the Mississippi River to the Pacific, 1853-78. 13 vols. Half leather.
 U. S. Geological Survey: Survey of the Territories, 1875-79. 6 vols. Cloth.
 U. S. Engineers' Exploration of the Great Basin of the Territory of Utah. 1876. Cloth.
 Messages and Documents, U. S. Geological Survey. 1882-84. 2 vols. Cloth.
 Explorations and Surveys for Ship-Canal, Isthmus of Tehuantepec, U. S. Navy Dept. 1872. Cloth.
 Study of Indian Languages, Bureau of Ethnology, Smithsonian Institution. 1880. Cloth.
 Japan Expedition by Com. M. C. Perry, U. S. Navy Dept. 2 vols. Cloth.
 North Polar Expedition, U. S. Navy Dept. 1876. Cloth.
 A Report on Irrigation, U. S. Dept. of Agriculture. 1893. Cloth.
 Ohio Geological Survey, 1873, 4, 5, and 8. 4 vols. Cloth.
 John Ericson, M.W.S.E. and Alderman Foreman, Chicago.
 Report on Chicago Transportation Subways. 3 books, cloth.
 American Railway Engineering and Maintenance of Way Association.
 Bulletins, 105, 107, 108, 109. Nov., 1908, Jan., Feb., March, 1909. 4 pamphlets.
 U. S. Geological Survey, Department of Interior.
 Bulletin, 367.
 U. S. War Department.
 Report of Chief of Ordnance, Vol. VI. Pam.
 U. S. Department of Agriculture.
 Circular, 150.
 Illinois State Geological Survey.
 Bulletin No. 9. Cloth.
 Colorado State Bureau of Mines.
 Report for 1907-'08. Pam.
 Pacific & Northwest Society of Engineers.
 Directory for 1909. By-Laws and Constitution. Leather.
 Merchants Association of New York.
 The House-fly at the Bar. Pam.
 Mr. Houston Lowe, Dayton, Ohio.
 Hints on Painting Structural Steel. Lowe. Cloth.
 Missouri State Geologist.
 Biennial Report of State Geologist, 1907-'08. Pam.
 Geology of Pike County, Mo. Cloth.
 Geology of Morgan County, Mo. Cloth.

Water Board, Brookline, Mass.

Report of Brookline Water Board for year ending Jan. 31, 1909. Pam.

Special Park Commission, Chicago.

Annual Report, 1908. Pam.

Board of R. R. Commissioners, Mass.

40th Annual Report, 1908. Cloth.

Wisconsin Geological Survey.

Maps of Lead and Zinc District.

National Chamber of Commerce, Washington, D. C.

Proceedings of Quarterly Meeting, April 7, 1909. Pam.

EXCHANGES.

American Society of Mechanical Engineers, Year Book, 1909. Cloth.

American Railway Engineering and Maintenance of Way Association, Bulletin 107, January, 1909. Pam.

Louisville Water Company, Reports for 1906-07. 2 pams.

Cleveland Engineering Society, Transactions, No. 2, The Cuyahoga Valley Viaduct of the N. R. R. R. Pam.

American School of Correspondence, Bulletin No. 10, March, 1909. Pam.

Engineering Association of New South Wales, Proceedings, 1907-08.

Junior Institution of Engineers, Westminster, Eng., Journal and Record of Transactions 27th session, 1907-08. Cloth.

Institution of Electrical Engineers, Journal, Vol. 42, Part 193, 1908. Pam.

Royal Society of New South Wales, Journal and Proceedings, Vol. 29, 1905.

Royal Philosophical Society of Glasgow, Proceedings, 1907-08. Pam.

Library of Congress, Copyright law in force July 1, 1909. Pam.

Moody's Magazine, New York, The Portland Cement Industry From a Financial Standpoint. E. C. Eckel. Cloth.

American Society of Civil Engineers, New York, Constitution and List of Members, February, 1909. Cloth.

Society of Engineers, London, Transactions, 1908. Cloth.

GOVERNMENT.

U. S. Geological Survey, Department of Interior. Pams.

Bulletins Nos. 368, 361, 364, 367.

Professional Papers, 58, 60, 61, 63.

Production of Spelter in U. S. in 1908.

35 Topographical Maps.

Water Supply and Irrigation Papers, 221, 226.

Mineral Resources of the U. S. in 1907. Vols. 1 and 2. Cloth.

Department of Agriculture, Circular No. 155.

Department of Commerce and Labor, Report of Superintendent of Coast and Geodetic Survey, 1908.

Commissioner of Labor, 22nd Annual Report, 1907, Labor Laws of the U. S.

Civil Service Commission, 25th Annual Report, 1908. Cloth.

Interstate Commerce Commission, 22nd Annual Report, 1908. Cloth.,

U. S. Engineers, Examination and Survey of Sacramento River.

Reports of Examination and Survey of San Joaquin River.
Stockton Channel, etc.

MEMBERSHIP

Additions to Membership:

	GRADE
Houser, Arthur M., Chicago.....	Active
Thompson, W. L., Las Cascades, C. Z.....	Active
Skeeles, George Y., Sioux City, Iowa.....	Active
Howard, F. H. P., Ravinia, Ill., Transfer from Junior to.....	Associate
Hoodwin, H. J., Chicago.....	Junior
Logan, Howard, Chicago.....	Active

Sauerman, H. B., Chicago, Transfer from Junior to.....	Active
Webb, Alexander R., Chicago.....	Junior
Luten, Daniel B., Indianapolis, Ind.....	Active
Waring, J. M. S., Chicago.....	Active
Huels, Frederick W., Madison, Wis.....	Active
Todd, Frank G., Chicago.....	Junior
Green, Paul E., Chicago.....	Active
Taylor, Fred C., Chicago.....	Junior
Broughton, H. P., Madison, Wis.....	Active
Dodge, Gordon F., Chicago.....	Active
Money, Fred B., Chicago.....	Active
Randolph, Robert I, Chicago, Transfer from Junior to.....	Active
Adgate, Frederick W., Chicago.....	Active
Pillsbury, C. S., Chicago.....	Junior
Collins, Ward O., Chicago.....	Active
Sullivan, Wm. T., Chicago.....	Junior
Dodge, Grenville M.....	Honorary

Deceased Members:

Adgate, George.....	Jan. 23, 1909
Ott, Harry J.....	Sept. 25, 1908
Reynolds, Wm. E.....	Feb. 24, 1909
Schaub, J. W.....	Mar. 30, 1909

Corrected Addresses:

Ashbaugh, L. E., Majestic Bldg., Denver, Colo.
 Batte, T. R., Jr., Gibbs Bldg., Houston, Texas.
 Borson, S. P. C., 528 Majestic Bldg., Denver, Colo.
 Canfield, Albert T., Amarillo, Texas.
 Clark, Frank S., 3346 Washington Blvd., Indianapolis, Ind.
 Dose, H. F., 55 Kellogg Bldg., Washington, D. C.
 Eastham, R. F., Flint Hill, Va.
 Ely, H. M., 921 Chamber of Commerce, Chicago.
 Eriksen, E. T., Hermiston, Ore.
 Evans, D. J., 1501 Monadnock Block, Chicago.
 Girand, James B., Wickenburg, Ariz.
 Harding, J. J., White Bldg., Seattle, Wash.
 Hain, Jas. C., Congress St. Bridge, Bridgeport, Conn.
 Kandeler, Theo., 1060 Winnemac Ave., Chicago.
 Lyons, James K., 1113 Empire Bldg., Pittsburg, Pa.
 Murphy, E. J., 93 Palisade Ave., Jersey City, N. J.
 Parker, W. A., St. J. & G. I. Ry., St. Joseph, Mo.
 Pruett, Wm. E., 608 New Nelson Bldg., Kansas City, Mo.
 Putnam, L. J., Elmhurst, Ill.
 Roeber, F., North Fond du Lac, Wis.
 Seymour, R. D., 210 Dooley Bldg., Salt Lake City, Utah.
 Spurling, O. C., Western Elec. Co., Hawthorne, Ill.
 Stearns, R. B., Kenilworth, Ill.
 Tedman, H. A., 515 Metropolitan Bldg., Minneapolis, Minn.
 Williams, L. E., Buffalo Dry Dock Co., Buffalo, N. Y.
 Woermann, J. W., 428 Custom House, St. Louis, Mo.

WESTERN SOCIETY OF ENGINEERS

SECRETARY'S OFFICE, LIBRARY, READING ROOM AND MEETING ROOMS
1735 Monadnock Block, Chicago.

LIST OF OFFICERS FOR 1909

President.....ANDREWS ALLEN
First Vice-President P. JUNKERSFELD
Second Vice-President.....O. P. CHAMBERLAIN
Third Vice-President.....W. F. M. GOSS
Treasurer.....A. REICHMANN

TRUSTEES

W. C. ARMSTRONG.....Term expires January, 1910
L. E. RITTER Term expires January, 1911
G. M. BRILL Term expires January, 1912
B. J. ARNOLD, W. L. ABBOTT, C. F. LOWETH.....Past Presidents.

The above named officers of the Society and three past presidents, constitute its Board of Direction.

Secretary and Librarian
J. H. WARDER

COMMITTEES

On Finance—P. Junkersfeld, A. Reichmann, John Brunner
On Publication—O. P. Chamberlain, C. B. Burdick, Wm. B. Jackson,
A. Bement, Ernest McCullough, E. N. Layfield, M. K. Trumbull, O. J. West.
On Library—W. C. Armstrong, L. J. Hotchkiss, E. N. Lake.
On Amendments—C. F. Loweth, W. L. Abbott, B. J. Arnold,
W. T. Reeves, M. K. Trumbull.
On Membership—L. E. Ritter, C. M. Denise, D. W. Roper.
On Entertainment—G. M. Brill, W. A. Hazard, James Lyman.
On Increase of Membership—S. T. Henry, F. W. Boldenweck,
C. W. Brooks, Arthur Lewis, M. W. Priseler.

THE ELECTRICAL SECTION

Wm. B. Jackson, Chairman, P. B. Woodworth, Vice-Chairman, for 1909.
K. B. MILLER.....1 year
E. N. LAKE.....2 years
W. L. ABBOTT.....3 years
Members of Executive Committee.

MEETINGS

Regular Meeting—1st Wednesday evening of each month except January
July and August.
Extra Meeting—Generally the 3rd Wednesday evening of each month except
July and August.
Electrical Section—Wm. B. Jackson, Chairman, generally the 2d Friday of
the month, October to May, inclusive.
Board of Direction—The Tuesday preceding the 1st Wednesday of each month.

NOTICE

From the dues of each member, \$2.00 is set aside as a subscription to the JOURNAL.

Journal of the Western Society of Engineers.

VOL. XIV.

JUNE, 1909.

NO. 3.

THE ILLINOIS COAL FIELD

BY A. BEMENT, M.W.S.E.

Presented April 7, 1909.

The Illinois Coal Field has produced 650,739,771 tons of coal having a final value of at least \$1,626,849,427, during which time, on a basis of 57 percent recovery, approximately 490,909,029 tons of coal have been wasted.

Illinois is the second largest coal producing state in the country, having a coal measure area according to the author's maps, of 37,-486 square miles, or 66.94 percent of the entire area of the state; also according to best recent conclusions, it would appear that it contains more unmined coal than any other in the country. Notwithstanding the magnitude and value of this great mineral product, the people in general know less concerning their coal deposits than those of almost any other state. There are two reasons for this, or more strictly speaking, a combination of two reasons:—

First, that previous geological survey undertaken many years ago, was more particularly directed to palaeontology than to geology, especially economic geology.

Second, that outcrops of rock formation are rare, owing to the greater part of the coal measures being covered by a thick mantle of drift.

Thus we have before us the unique fact that the professional geologist has contributed but little to the considerable knowledge which we possess of our Illinois coal resources. The practical business man, however, has proceeded with exploration and development, so that notwithstanding the absence of geological guidance he has exploited Illinois coal fields on a very large scale. Thus to the engineer rather than to the geologist are we indebted for our present knowledge, but the time has now arrived when the services of the best talent available is demanded.

Mining in Illinois has been a very simple proposition. Wasteful extravagance and crude methods have prevailed, but the general awakening of the people of the whole country to the necessity for the conservation of natural resources, and to the fact that Illinois

mining is advancing into territory of thick seams which lie at considerable depth and produce a dangerous amount of gas, present many new problems of an engineering as well as of a commercial nature.

From the standpoint of future posterity, it is probably fair to say that one of the misfortunes of the Illinois coal field was the great abundance of cheap coal available in the past, as this led to extravagance and wasteful mining methods.

While Illinois contains a very large amount of coal, it is not all available for mining under present conditions, and as a matter of fact, the thinner and deeper coal will always be at a disadvantage as long as it may meet competition with more cheaply mined coal from this or other fields. This is a fact that is usually not understood in its full significance. Really the question is not how much reserve coal have we, but how much is there that may be mined to advantage in competition with other fields. When the problem is considered from this standpoint, it presents itself in a strange and startling light. For example, some three or four years ago in reporting on a large coal proposition for Illinois, the author stated that the area of coal available to purchase adaptable for competition under the then prevailing conditions, was but one-half of one percent of the entire field. Such territory would yield under present methods of mining, a recovery of approximately as much coal as has been already produced, equal to only about ten years' production at the present rate of consumption. In this same line, Dr. I. C. White has recently directed attention to the early exhaustion of the Pittsburg coal seam, and shown what it will mean to the industrial localities depending upon this great seam for their fuel supply.

Thus far Illinois has not suffered to the extent that other states have from large mine casualties, because there is only a comparatively small amount of gas generated, although operation of the deep mines in the No. 7 seam in Franklin County has been attended thus far with very disastrous results, notwithstanding that only three mines have reached a fair stage of development. The reason therefor is, that a larger quantity of gas is given off in these mines, which together with the reckless disregard of safety that prevails, changes what would otherwise be a good safe field to a very dangerous one, giving promise that if present disregard for safety continues, that it will distinguish itself by such appalling disasters as have occurred recently in Pennsylvania and West Virginia. The chief cause of such accidents is the excessive use of powder, which is on the increase and threatens to become still more serious unless proper restrictive measures are enforced. Fig. 1 illustrates the increasing use of powder per ton of coal produced.

Maps Nos. 1 and 2, showing areas of principal coal seams and thickness of seams, while, of course, subject to revision, possess some considerable degree of accuracy and real value. When our new State Geological Survey has proceeded further with the work

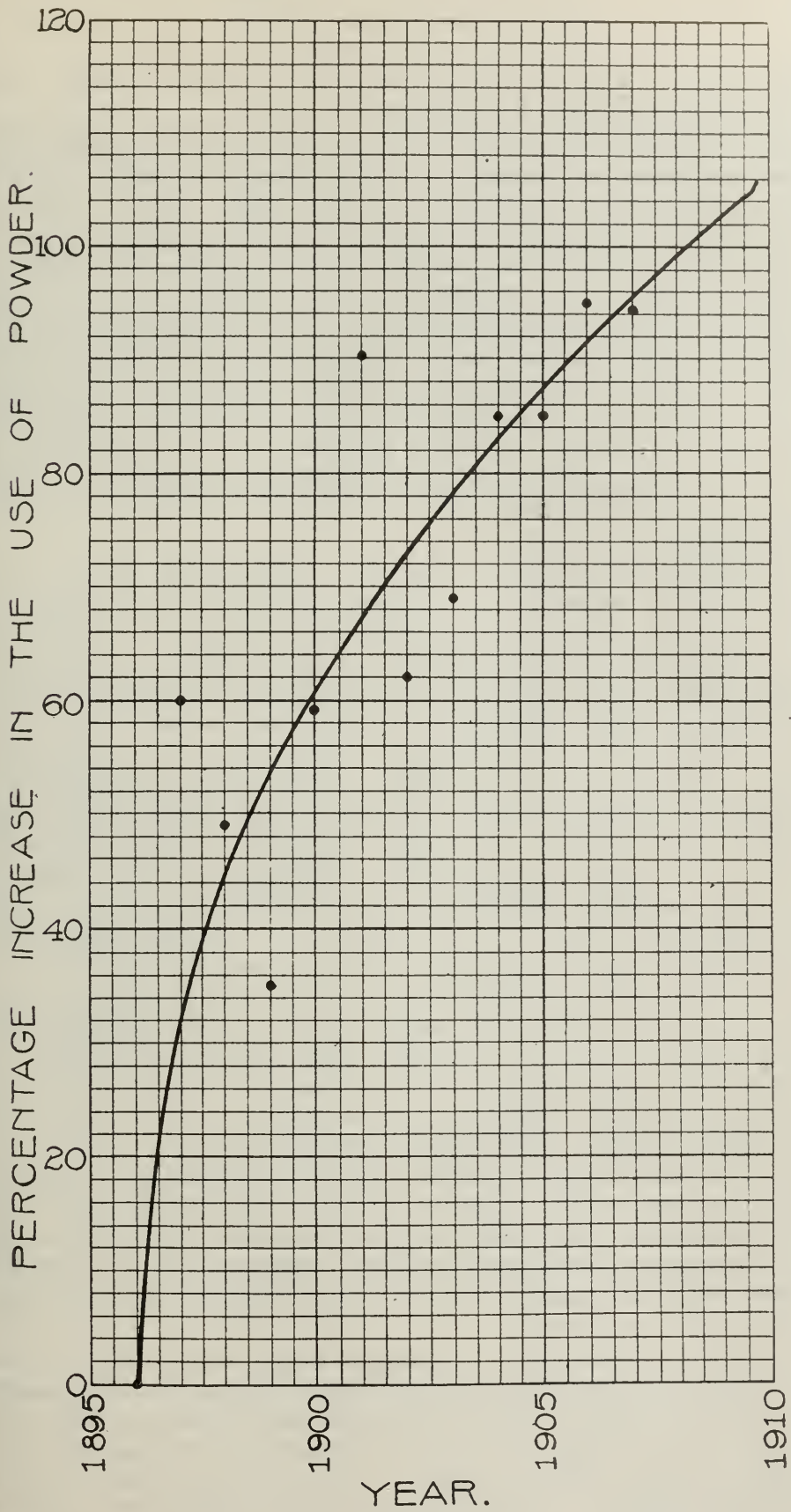


FIG. 1.

Diagram illustrating Increase for the past Eleven Years in amount of Powder required per Ton of Coal.

laid out by Dr. Bain, it will be possible to make still better maps from data that will then be available.

Only two divisions have thus far been definitely recognized in the Illinois coal measures, called upper and lower, also barren and productive, and it was reported by the first State Survey under the direction of Dr. Worthen, that there are sixteen coal seams present in these measures. It is probable, however, that the number is considerably more. All of the seams of importance are in the lower measures. This numerical classification was established years ago, and it has been almost universally used, although in reality they have no greater significance than that of local names, but in the absence of other designations, these numbers are employed in this paper, which does not attempt to present anything new of a geological nature, the author's object being to put together such data as available for present use, hoping that the near future will present more complete and accurate version.

The important producing seams are designated as Nos. 1, 2, 5, 6 and 7. What is known as seam No. 5 is operated extensively in three different localities in the following counties:—Fulton and Peoria; Sangamon, Menard and Logan; and Saline; yet there is no assurance that these beds are the same seam, as it cannot be directly traced, the localities being separated from each other. The No. 6 seam, however, in the western part of the state is so persistent and uniform in thickness from the lower part of Sangamon, that it may be readily traced as far south as Perry County without there being any doubt of its identity. Recently, however, a question has arisen whether or not the seam operated in Williamson, Franklin and the eastern part of Perry and Jackson counties, known as No. 7, is the same bed as No. 6, and it is the conclusion of Dr. Bain, State Geologist, and Mr. Frank W. DeWolf, Assistant Geologist, that it is the same seam as No. 6, that an abrupt anticline with its axis north and south at the town of Duquoin, has in the past caused people to conclude that there were two different seams. Inasmuch, however, as to the present time the operations in Perry County to the east of Duquoin, and in the eastern part of Jackson as well as Williamson and Franklin counties have been considered as being in seam No. 7, and as this is the version of the matter which has been accepted, this paper assumes this coal body to be No. 7, although Table No. 1 shows the output individually, also in conjunction with that of No. 6 seam, and in the map showing areas, this coal bed in these four counties may be considered as No. 6 instead of 7, thus either version may be employed.

Map No. 1 shows areas of principal coal seams. The presentation of areas of this character in any other state but Illinois would be very difficult. Here, however, owing to the persistence, uniformity in thickness and reliability of the various seams, it is possible to indicate their presence with far greater accuracy than would usually be considered possible. The data which has been employed is from the

State Mine Inspection records, various mining operations and prospect borings, supplemented by the author's experience and observation in the field. The statement as to uniformity and persistence of seams, applies particularly to the western portion of the state, so that in prospecting, the problem is not so much to discover a desirable bed, as to prove the presence and condition of the prevailing bed of the district. For example, the author in the case of a continuous field of 65,000 acres, had sufficient confidence in the territory to report the undoubted presence of the seam at desirable thickness and condition, which was afterwards verified by borings. proving the accuracy of previous opinion.

TABLE NO. 1.
OUTPUT OF PRINCIPAL COAL SEAMS FOR 1907.

Seam No.	Detailed Output.		Total Output of Seams.		Including No. 7 in Williamson and Franklin County Field with No. 6.	
	Tons	Percent.	Tons.	Percent.	Tons.	Percent.
1.	667,601	1.36	667,601	1.36	667,601	1.36
2.	6,293,740	13.10	6,293,740	13.10	6,293,740	13.10
3.	11,688	0.24	11,688	0.24	11,688	0.24
5.			11,405,436	23.73	11,405,436	23.73
5. Saline.....	1,711,825	3.56				
5. Sangamon, Logan, Menard.	6,141,040	12.77				
5. Fulton, Peoria.	3,234,725	6.74				
5. Miscellaneous..	317,846	0.66				
6.	20,899,473	43.64	20,899,473	43.64		
6. Including Williamson and Franklin					28,365,718	59.18
7.			8,509,354	17.70		
7. Williamson and Franklin	7,466,245	15.54				
7. Miscellaneous..	1,043,109	2.16			1,043,109	2.16
14.	11,329	0.23	11,329	0.23	11,329	0.23
Total	47,798,621	100.00	47,798,621	100.00	47,798,621	100.00

Another characteristic is that in a general field there is usually but a single seam that may be profitably worked at present. The eastern edge of the basin which is largely in Indiana and partially in Illinois, is quite different. The seams therein can usually be depended upon as being irregular, and in this respect differing with the western edge of the basin. Saline County is far enough east to be included in the irregular territory, but extensive prospect borings in the locality have defined the presence of the seam with great accuracy, and the same applies in a measure to the locality in Crawford County, while mining operations and extensive prospecting in Vermilion County has quite fully defined the thicker part of the field.

As a matter of fact the great uniformity in thickness and persistence of a seam in the locality in which it is known to be present are such, that in former years many shafts were sunk from 200 to

700 feet without previous prospecting, and the principal cause of failure, (but a small percentage) consisted in getting outside the limits of the bed. For illustration, a number of shafts 720 feet deep at Pana in Christian County reached the No. 6 seam 8 feet in thickness. Following this lead in an effort to reach the "Pana" seam, a shaft was sunk about 13 miles north at the town of Assumption. It, however, probably penetrated a preglacial valley in which the seam was absent. Sinking, however, was continued to a depth of 1,008 feet, when two seams were encountered, which are usually regarded as being Nos. 1 and 2, or as the operator of the mine considers, an upper and lower split of seam No. 2. In this general locality there were some two or three other failures, due to getting beyond the boundary of the bed into this same valley which is defined on Map No. 1 as extending from Madison, across Montgomery and Christian Counties, and indicated as being underlain with seams Nos. 1 and 2.

The Illinois coal measures have been reported as having a thickness of 1200 feet in the southern part of the state. This however, is probably underestimated, as the depth is no doubt, 200 or 300 feet greater, as the measures are much thicker in the south. For example, Seam No. 5 of Southern Illinois and No. 9 of Western Kentucky are considered as identical, and there is no assurance but what No. "9" should bear a higher number. To the north, George H. Ashley estimates the thickness at 800 feet; 600, however, may be more nearly correct.

The horizon of seam No. 2 has been identified by Dr. David White from the northern to the southern end of the state along the western outcrop; the coal bodies below it, however, are but little understood. Several seams present in the southern part are absent in the north. In the territory attributed on Map No. 1 to seams Nos. 1 and 2, it is probable that the two horizons lie close together. For illustration the mine at Assumption in Christian County, penetrates two seams lying at about 2 feet to 20 feet apart, so that both are operated from the same bottom. At the town of Lovington in Moultrie County, in a boring 886 feet deep, penetrating a body of coal 8.4 in. in thickness, the appearance of the core suggests the probability of one coal body being present above the other with no intervening rock formation. This boring passed through eleven seams in a depth of 856 feet. Below this and above the thick coal, there were two other seams 3.3 in. and 3.4 in. in thickness, and at the town of Mattoon in Coles County, a mine long since abandoned, formerly operated what was considered seam No. 2 which had a thickness of 3 ft. 5 in. at a depth of 904 feet. These examples, together with borings for wells and other prospect holes, appear to indicate that in the center of the basin in the territory shown on Map No. 1 as being underlain by seams Nos. 1 and 2, and on Map No. 2 indicated as being underlain by unknown coal, such important coal bodies as present are at a considerable depth, and probably of irregular extent and thickness, thus the thicker beds are in the lower measures.

Faults and other disturbances are not numerous and have had practically no effect on mining operations, although some pronounced displacements of strata are recognized, the most important one an anticlinal fold extending in a southerly direction, enters the coal measure formation east of the city of LaSalle in the county of that name, where the St. Peter's sandstone is brought to the surface, as may be observed at Starved Rock and Deer Park Canon. This disturbance appears to extend through the counties of Champaign, Douglas, Coles, Clark, Crawford and Lawrence as indicated on maps Nos. 1 and 2. This is the line along which the producing oil fields are located, and for purpose of illustration, the coal measure formation is shown as being absent by a long gap to the north, and in the southern counties by small patches co-incident with the oil fields. There is a large fault extending on an east and west line through Gallatin and lower Saline counties, described by Frank W. DeWolf in Bulletin No. 316 of the United States Geological Survey. Its location, however, is south of the thick coal bed, although there are accompanying displacements of small magnitude further north, which do affect the bed to a moderate extent. An anticlinal fold tending north and south at Duquoin in Perry County has thrown out the coal seam at that point. In the mine at Assumption in Christian County and in Williamson County, the author has observed many small faults from a fraction of to a few inches displacement, the most seriously disturbed condition so far as known to affect a coal seam, is probably in Fulton and Peoria counties as described by J. A. Udden, page 255, Bulletin No. 8, State Geological Survey.

With the exception of the Northern and Wilmington fields, the deep mine at Assumption and one at Bloomington, all mining is by pillar and room method, and these operations produce 84.94 per cent of the output. The other 15.04 percent is furnished by the long wall operations of the Northern and Wilmington fields, in which it has been considered that a recovery of 95 percent of the coal is effected. Mining methods in all but these two latter fields under present conditions are necessarily very wasteful, as pillars are seldom or ever drawn, it being cheaper to open new territory than to get an equal tonnage from pillar coal.

The small country mines are very largely drifts at the hillside into the outcropping of the seam. With one or two exceptions, however, all of the shipping mines in Illinois are operated by shaft. In the early history of mining there were a considerable number of slopes in the outcrop, especially in Grundy, Peoria, Fulton and St. Clair counties, but development has advanced away from the outcropping, so that shafts are necessary, and Illinois may be considered a locality of deep mining, as shafts range from less than 100 to 1,000 feet in depth.

The depth of No. 2 seam in the Wilmington Field where now operated, is from 90 to 196 feet.

In the Northern Field, shafts are from 300 to 465 feet.

In Jackson County about 150 feet.

In Seam No. 5 in Fulton and Peoria counties, from 75 to 195 feet.

In the Springfield District from 75 to 250 feet.

In Saline County from 40 to 340 feet.

In Seam No. 6 the depth varies from 50 to 885 feet.

In Seam No. 7 from 30 to 630 feet.

Table No. 2 shows the distribution of output according to thickness of seam:—

TABLE No. 2.

	Tons 1908.	Percentage.
Thin coal, under 4 feet.....	6,829,161	13.86
Medium coal, 4 to 6 feet.....	5,567,787	11.30
Thick coal, 6 to 8 feet.....	31,514,662	63.96
Very thick coal, over 8 feet.....	5,360,842	10.88
	49,272,452	100.00

There are 411 mines which ship their coal by rail, of which 47 are operated long wall and 364 by the pillar and room method, giving an average annual output per mine of 148,795 tons for the former and 108,361 for the latter, with about 700,000 tons from one shaft as a maximum annual output, which has been obtained by a pillar and room mine. In addition there are 522 small local mines, making a total of 933.

The following estimates have been made of the original quantity of coal before mining began ;

Authority.	Tons.
F. W. DeWolf, Assistant State Geologist.....	136,960,000,000
M. R. Campbell, U. S. Geological Survey.....	240,000,000,000
The author	201,399,808,000

The figure proposed by the author was arrived at by measuring the areas on a map of a scale of one-half inch to the mile, and taking the known or estimated thickness of the seam which gives the quantity in Tables Nos. 3 and 4.

TABLE No. 3.

KNOWN COAL AREAS OF ILLINOIS.

Coal Areas.	Coal Beds.	Square Miles.	Thickness in feet.	Tons.
1	Very thick	674	9.0	6,211,584,000
2	Thick	3,883	7.0	27,833,344,000
3	Medium	12,546	4.0	51,388,416,000
4	Thin	10,184	3.0	31,285,248,000
	Unknown	10,199	1.5	15,665,664,000
Total.....		37,486		132,384,256,000

The various areas arbitrarily designated as Nos. 1 to 4, inclusive, are also underlain by other coal beds, and Table No. 4 is based on an assumption that these areas also contain quantities attributed to them.

TABLE No. 4.

ESTIMATED ADDITIONAL QUANTITY OF COAL.

Coal Areas.	Square Miles.	Estimated Thickness in feet.	Tons.
1	674	6	4,141,056,000
2	3,883	4	15,904,768,000
3	12,546	3	38,541,312,000
4	10,184	1	10,428,416,000
Total.....	27,287		69,015,552,000

The total number of tons contained in the above two tables, is 201,399,808,000.

Calculation shows that about one-half of one percent of the amount of coal in Illinois has been exhausted, and such figure as this is liable to cause one to feel that the supply will last a very long while. In the past people have been led to believe that our coal would last almost "forever," which gave rise to such expressions as "inexhaustible supply," "fuel reserve to last for untold ages," etc. In this connection Dr. I. C. White has recently shown, that when the Pittsburg coal seam is exhausted, certain to occur in not much to exceed fifty years with present mining methods, the industries dependent thereupon will suffer seriously, and it seems reasonable to conclude that such an outcome in itself would be sufficient to rob these localities of the industrial supremacy they now enjoy. In Illinois the 25 percent of coal produced from the thin and medium thick seams is shipped away, and the state is practically dependent for its fuel supply upon the product from thick seams which contained originally about 34,000,000,000 tons, of which 930,557,872 have been exhausted; thus the fuel supply suitable for use under present economic conditions is only 16 percent of the original, for while the coal remaining is about 99.5 percent, the really desirable portion is, as above stated, but 16 percent.

Fig. 2 illustrates graphically the competition between the thin and thick coal beds of the state. After 28 years the leading thin and medium thick coal areas in the northern part of the state although nearest markets, have an output of approximately 1,500,000 tons per annum, while in the same period of time, with no better start Williamson County has arisen to nearly 5,250,000 tons per annum, and the average of four of the leading counties in the central part of the state operating in seam No. 6, has increased to an output of nearly 4,500,000 tons, and Saline County has gone from 350,000 to 2,500,000 tons in three years.

Table No. 1 shows the coal production for the state in both tons

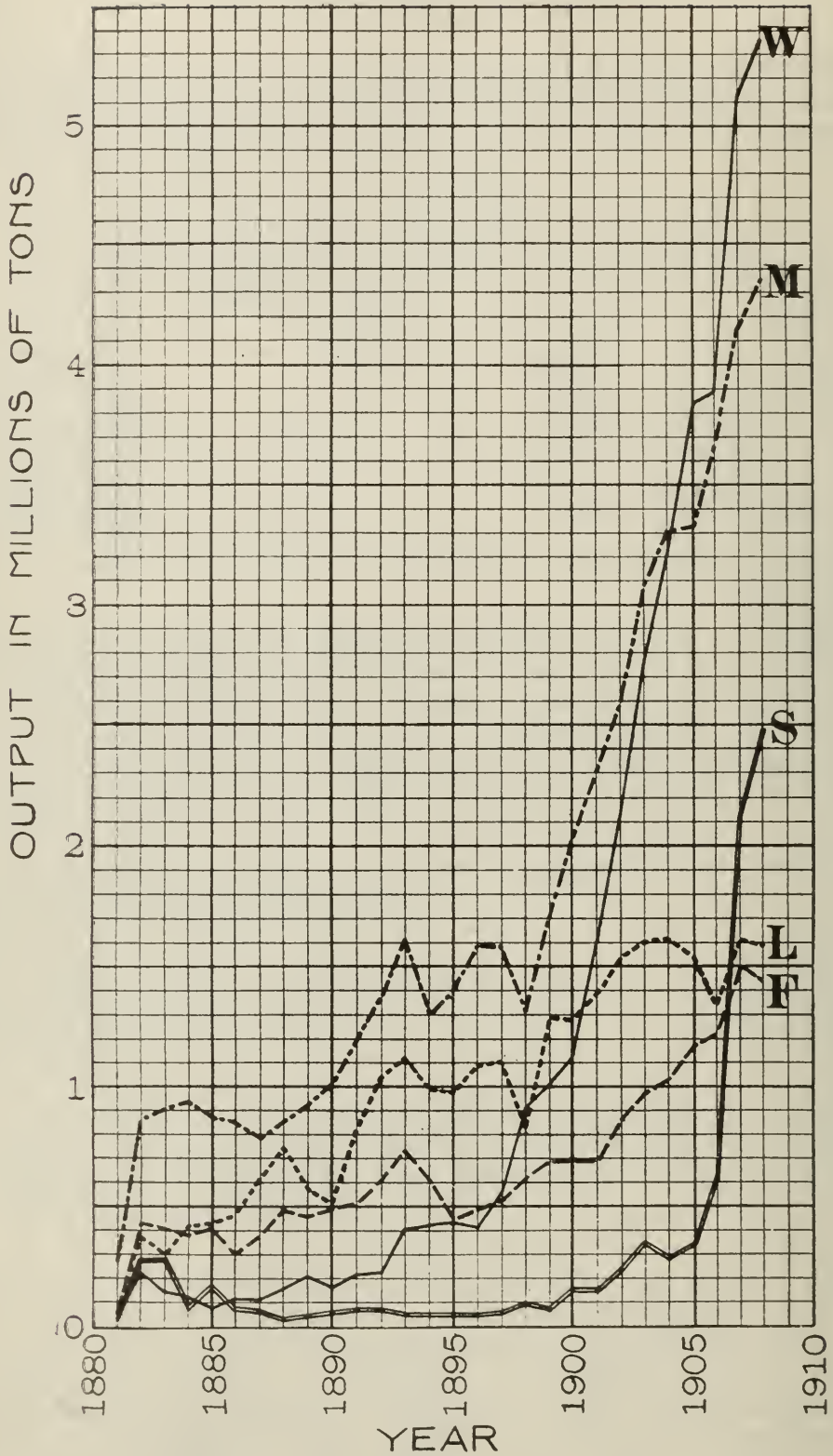


FIG. 2.

Rate of Development between Thick and Thin Coal Localities.

W Williamson County—9 ft. Seam.

M Average of Sangamon, St. Clair, Macoupin and Madison Counties—7.5 ft. Seam.

S Saline County—6 ft. Seam.

L Average of Bureau and Grundy Counties—3.25 ft. Seam.

F Average of Peoria and Fulton Counties—4 ft. Seam.

and percentages from the different seams, for the year 1907. As indicated, there is a distinction made for different fields, in which seam No. 5 is credited with furnishing the output. Likewise with No. 7 a separation is also made. Thus the first column presents figures of this detailed classification, the second, the totals produced for each seam. As before mentioned, in recent reports of the State Geological Survey, it is considered that the field in Williamson, Franklin, Eastern Perry and Jackson counties operates seam No. 6 instead of No. 7 as formerly believed. Upon this basis the output from the Williamson and Franklin county field as shown on the maps, has been included with the output from the No. 6 seam indicated by the third classification, which credits seam No. 6 with a production of upwards of 28,000,000 tons for the year 1907, or 59.18 percent of the whole output of the state.

The center of coal production in Illinois has steadily moved from north to south. Continuous detailed records of Illinois coal production only began in 1881, therefore it was impossible to extend the tables presented herewith prior to that time. Early records of coal mining, according to the Coal Report of 1902 are very meager. The first mention apparently of coal shipment was from Jackson County in 1810; again in 1832 several boat loads were sent south via the Mississippi River; in 1833 about 6000 tons were reported as having been mined in St. Clair County and hauled by wagon to St. Louis. The United States census in 1840 states that 16,968 tons were produced in that year; that of 1860 gives a production of 568,000 tons. The next record is that of the census of 1870, wherein the output is stated to be 2,624,163 tons. The first state report, in 1881, places it at 2,937,776 tons. In arriving at the total coal production given in this paper, a curve was plotted from the data available prior to 1870, from which the output for this period was determined. Between 1870 and 1880 the production has been considered as an annual average of that of 1870 and 1880. From 1881 to 1908, figures are from the Coal Report for each year. Fig. 3 shows graphically the increase in production for the last 28 years.

The center of output in the state has gradually advanced from north to south as shown in Table No. 5. In the year 1881, LaSalle County led in output with 624,900 tons; in the next year it still held place with over 2,000,000, after which the center of production moved south until the county leading in 1907 and 1908 is at the extreme southern end of the state. During the period of 28 years, Macoupin County has led in production 8 times, Sangamon 7, St. Clair 6, LaSalle 3, Vermilion 2 and Williamson 2, and is still being held by Williamson. Thus the center of production has steadily diverged from principal markets because of advantages of thick coal. LaSalle County now ranges as a producer from a thin seam, but in earlier years a comparatively small body of very thick coal was extensively operated at the town of Streator, and it was this which gave LaSalle its lead.

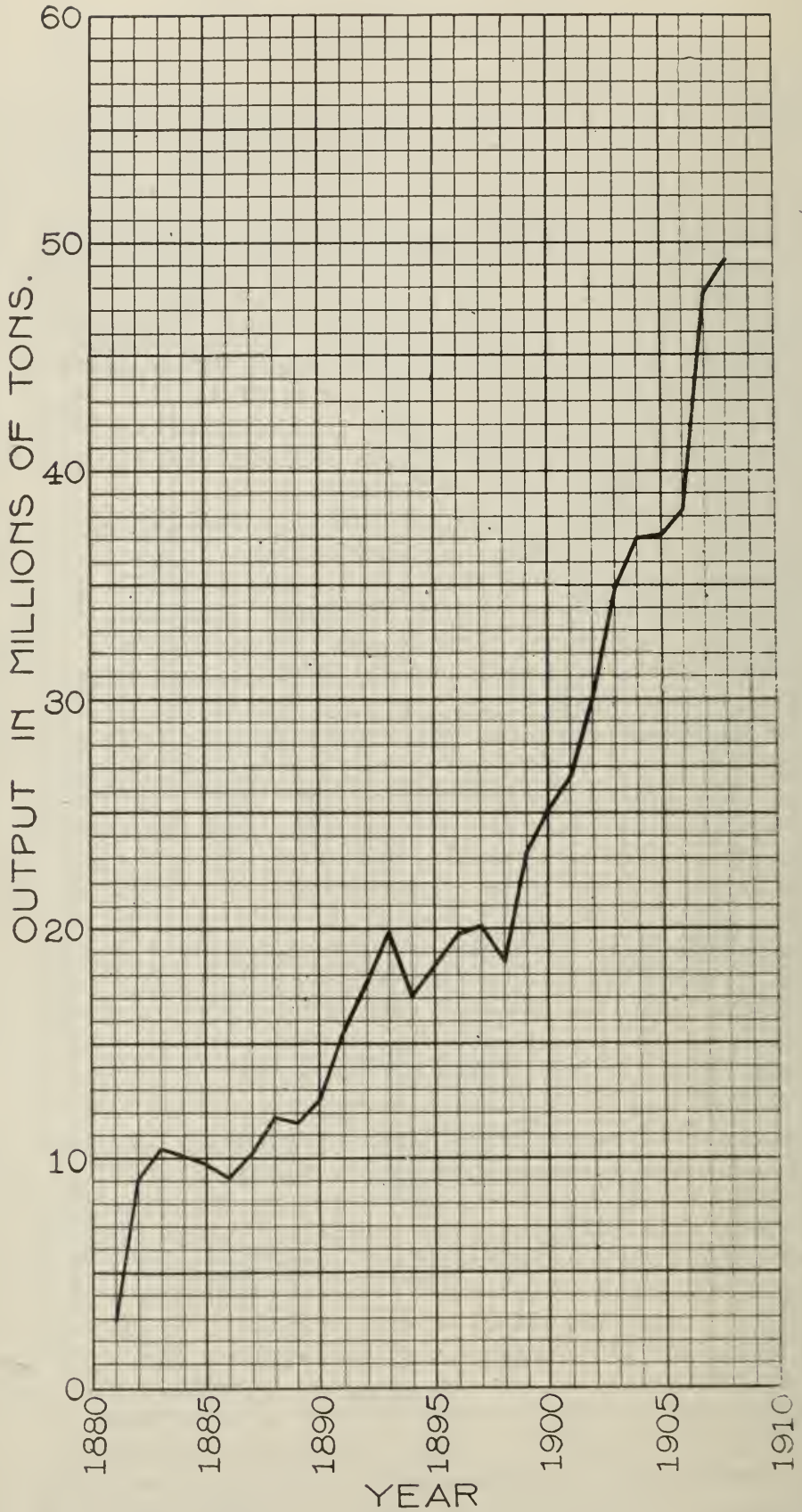


FIG. 3.

Diagram showing Coal Production in Illinois from 1881 to 1908.

TABLE NO. 5.

COUNTIES LEADING IN PRODUCTION FROM 1881 TO 1909.

Chronological Arrangement			Arranged According to Tonnage.		
Year.	County.	Tonnage.	County.	Year.	Tonnage.
1881	LaSalle	624,900	Williamson	1908	5,367,140
1882	LaSalle	2,365,000	Williamson	1907	5,266,452
1883	Macoupin	1,233,200	Sangamon	1904	4,516,358
1884	Macoupin	1,164,409	Sangamon	1905	4,395,050
1885	St. Clair	1,202,549	Sangamon	1903	4,386,526
1886	Macoupin	1,085,539	St. Clair	1906	4,168,019
1887	LaSalle	1,125,235	Sangamon	1902	3,672,987
1888	St. Clair	1,184,579	Sangamon	1901	2,919,223
1889	Macoupin	1,202,187	Sangamon	1900	2,519,911
1890	Macoupin	1,369,919	LaSalle	1882	2,365,000
1891	St. Clair	1,595,839	Vermilion	1899	2,221,867
1892	Macoupin	1,823,136	St. Clair	1893	2,133,870
1893	St. Clair	2,133,870	Macoupin	1896	2,097,539
1894	St. Clair	1,623,684	Vermilion	1897	2,000,623
1895	Macoupin	1,948,992	Macoupin	1895	1,948,992
1896	Macoupin	2,097,539	Macoupin	1892	1,823,136
1897	Vermilion	2,000,623	Sangamon	1898	1,763,863
1898	Sangamon	1,763,863	St. Clair	1894	1,623,684
1899	Vermilion	2,221,867	St. Clair	1891	1,595,839
1900	Sangamon	2,519,911	Macoupin	1890	1,369,919
1901	Sangamon	2,919,223	Macoupin	1883	1,233,200
1902	Sangamon	3,672,987	St. Clair	1885	1,202,549
1903	Sangamon	4,386,526	Macoupin	1889	1,202,187
1904	Sangamon	4,516,358	St. Clair	1888	1,184,579
1905	Sangamon	4,395,050	Macoupin	1884	1,164,409
1906	St. Clair	4,168,019	LaSalle	1887	1,125,235
1907	Williamson	5,266,452	Macoupin	1886	1,085,539
1908	Williamson	5,367,140	LaSalle	1881	624,900

Table No. 6 gives the output for each county from 1881 to 1907, inclusive, from which it appears that Sangamon County has produced over 52,000,000 tons, St. Clair being second, Macoupin third and LaSalle fourth in the list, illustrating again in a striking manner the advantage of thick coal seams, even Williamson County which is a new field and producing on a large scale only a few years, occupying seventh place.

TABLE NO. 6.

COAL PRODUCTION OF ILLINOIS COUNTIES FROM 1881 TO 1907, INCLUSIVE.

Arranged According to Counties.		Arranged in Order of Tonnage.	
Counties.	Tons.	Counties.	Tons.
Bond	2,299,973	Sangamon	52,754,789
Brown	20,226	St. Clair	50,994,386
Bureau	25,011,119	Macoupin	46,431,324
Calhoun	81,455	LaSalle	38,493,630
Cass	143,112	Vermilion	37,725,601
Christian	14,635,823	Madison	34,303,262
Clinton	9,778,275	Williamson	29,881,544
Coles	144,932	Grundy	27,122,051
Edgar	65,103	Bureau	25,011,119
Effingham	796	Fulton	17,900,619
Franklin	1,392,643	Perry	17,880,094
Fulton	17,900,619	Jackson	17,491,385

June, 1909

TABLE NO. 6.—Continued.

Arranged According to Counties.		Arranged in Order of Tonnage.	
Counties.	Tons.	Counties.	Tons.
Gallatin	972,718	Peoria	16,741,393
Greene	305,193	Christian	14,635,823
Grundy	27,122,051	Marion	13,584,554
Hamilton	21,891	Clinton	9,778,275
Hancock	177,358	Mercer	9,516,711
Hardin	64	Menard	7,919,430
Henry	3,855,786	Randolph	7,756,345
Jackson	17,491,385	Livingston	7,728,428
Jasper	20,078	Will	5,713,735
Jefferson	379,311	Logan	5,615,326
Jersey	71,820	Saline	5,531,780
Johnson	124,497	Montgomery	5,337,836
Kankakee	1,863,342	Macon	4,645,487
Knox	1,449,022	McLean	4,292,257
LaSalle	38,493,630	Henry	3,855,786
Livingston	7,728,428	Woodford	3,743,886
Logan	5,615,326	Tazewell	3,472,247
Macon	4,645,487	Rock Island	3,208,241
Macoupin	46,431,324	Bond	2,299,973
Madison	34,303,262	McDonough	2,114,159
Marion	13,584,554	Kankakee	1,863,342
Marshall	601,971	Shelby	1,449,306
Menard	7,919,430	Knox	1,449,022
McDonough	2,114,159	Franklin	1,392,643
McLean	4,292,257	Washington	1,223,775
Mercer	9,516,711	Gallatin	972,718
Montgomery	5,337,836	Stark	646,626
Morgan	131,260	Marshall	601,971
Peoria	16,741,393	Scott	511,887
Perry	17,880,094	Putnam	446,678
Pike	135	Warren	415,490
Putnam	446,678	Schuyler	387,551
Randolph	7,756,345	Jefferson	379,311
Rock Island	3,208,241	Greene	305,193
Saline	5,531,780	Hancock	177,358
Sangamon	52,754,789	Coles	144,932
Schuyler	387,551	Cass	143,112
Scott	511,887	Morgan	131,260
Shelby	1,449,306	Johnson	124,497
Stark	646,626	Calhoun	81,455
St. Clair	50,994,386	Jersey	71,820
Tazewell	3,472,247	Edgar	65,103
Vermilion	37,725,601	Hamilton	21,891
Wabash	13,712	Brown	20,226
Warren	415,490	Jasper	20,078
Washington	1,223,775	White	14,828
White	14,828	Wabash	13,712
Will	5,713,735	Effingham	796
Williamson	29,881,544	Pike	135
Woodford	3,743,886	Hardin	64

Table No. 7 shows the production in tons for all counties in the year 1907, giving the number of mines in each county and the average output per mine for the county. The majority of these mines are very small, producing for local trade only. For example, Mc-

Donough County with 54 mines has an average of only 859 tons per mine while Macoupin has an average of 156,555 tons in which two mines are included which have an output of about 700,000 tons per annum.

Compared with other coal fields of this country, the quality of Illinois coal occupies an intermediate position. Table No. 8 gives the chemical composition of the various important seams and localities where extensively worked. This table presents the coal seams as they lie in the ground and possesses a considerable degree of accuracy, although, of course, more detailed study will furnish better values. The author is indebted to Dr. H. Foster Bain, Director of the Illinois Geological Survey for some data concerning Seam No. 2 in the Wilmington and Northern Fields, and Seam No. 5 in the Peoria and Fulton County Field.

As a general proposition in Illinois, the quality of coal seams increase with depth, the lower ones being superior to the upper. There is also an increase in quality from the north to the south, the beds in the southern part of the state being superior, as a general proposition, to those in the north; this is more particularly true of the heating power content. A higher grade of fuel is produced in Illinois than probably realized by the general public. For example carefully prepared lump coal from Saline County compared with equally well prepared Hocking Valley coal of Ohio is presented in the following tabulation:—

	Hocking Valley, Ohio, Prepared Coal.	Saline County, Illinois, Lump Coal.
Moisture	7.28	6.75
Ash in dry coal.....	6.40	6.07
Heating power per pound in B. t. u. of the pure coal.....	14,341	15,094
Heating power per pound in B. t. u. of the moist coal.....	12,365	13,181
Relative value.....	0.95	1.00

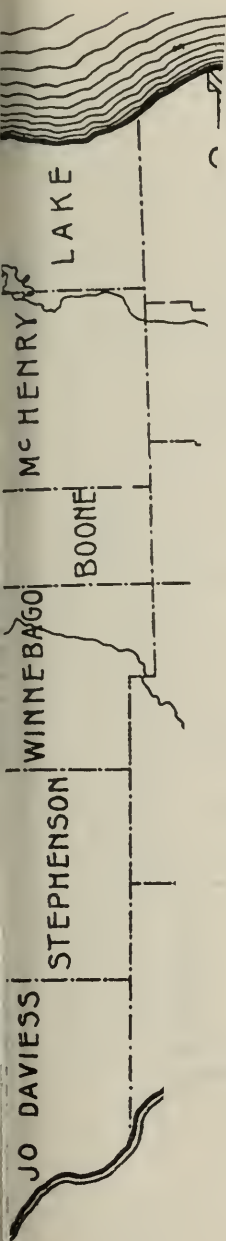
The writer at one time had a sample of coal submitted to him that was reported to have come from a thin seam in Johnson County, which is at the extreme southern outcrop of the coal basin in Illinois, and when analyzed, this coal gave a moisture content of 2.76 and dry ash, 3.40. The pure B. t. u. lay somewhere between 15,500 and 15,700, and the appearance of the sample indicated a superior quality of fuel.

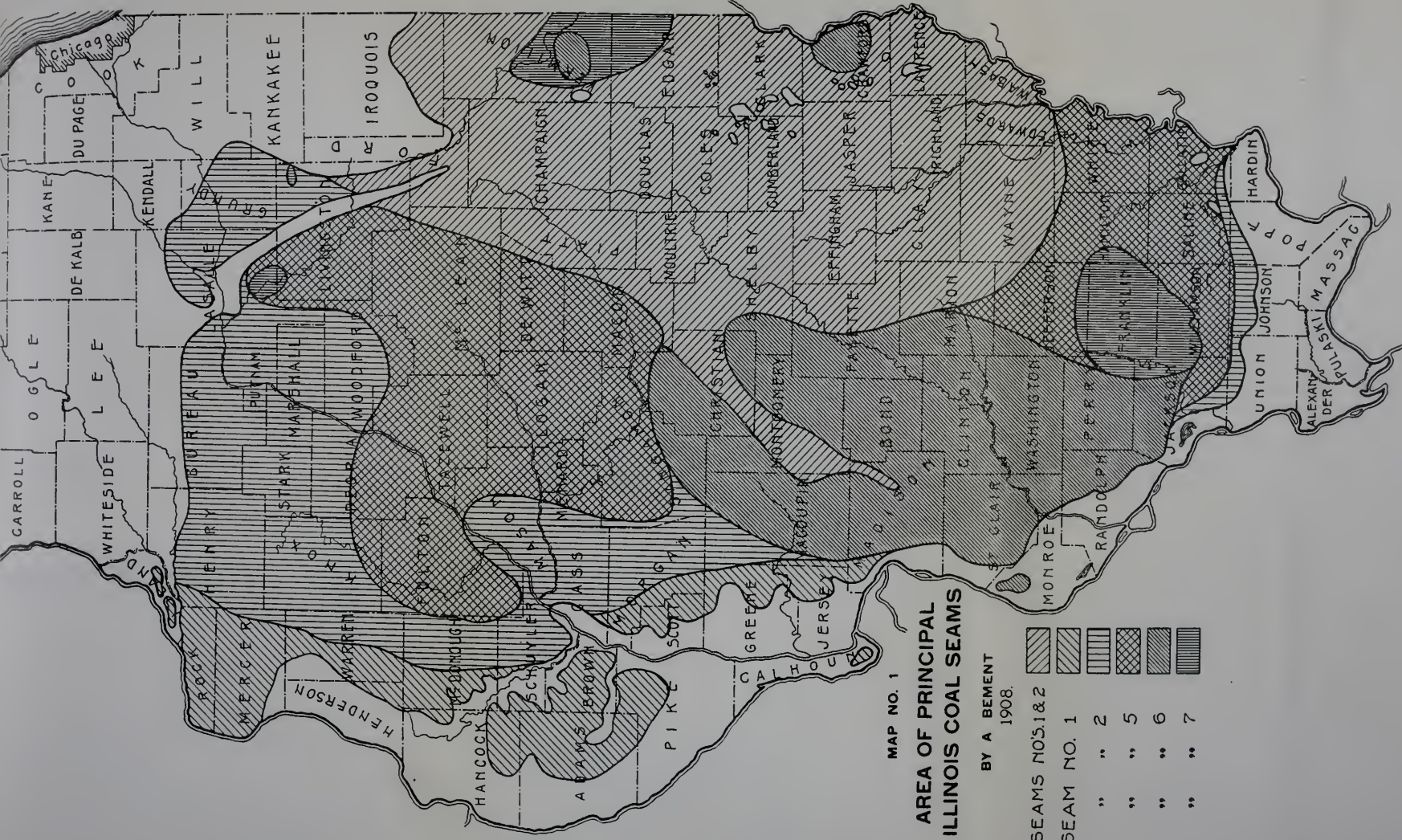
A high grade fuel is prepared in the form of washed and sized coal. There are two localities which lead in this product, one is in Williamson County and the other in Central Illinois in the lower part of Macoupin and upper portion of Madison county, and Table No. 9 shows the chemical composition of these fuels.

TABLE NO. 7.

AVERAGE PRODUCTION PER MINE, SHIPPING AND LOCAL, FOR ALL COUNTIES
FOR 1907.

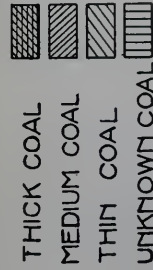
County.	Total Production.	Number of Mines.	Average Tons per Mine.
Bond	136,967	2	68,483
Brown	380	2	190
Bureau	1,891,900	18	105,105
Calhoun	4,450	1	4,450
Cass	1,625	2	812
Christian	1,235,566	8	154,446
Clinton	1,061,410	7	150,630
Edgar	790	1	790
Franklin	863,165	8	107,895
Fulton	1,993,401	73	27,307
Gallatin	88,908	10	8,890
Greene	3,830	3	1,276
Grundy	1,327,197	22	60,327
Hancock	11,532	7	1,647
Henry	173,587	34	5,105
Jackson	705,363	18	39,187
Jefferson	10,060	2	5,030
Jersey	2,040	2	1,020
Johnson	2,900	2	1,450
Kankakee	37,828	1	37,828
Knox	42,668	42	1,016
LaSalle	1,644,686	39	42,171
Livingston	269,811	9	29,979
Logan	478,015	4	119,503
Macon	296,329	5	59,265
Macoupin	4,227,267	27	156,565
Madison	3,573,163	34	105,093
Marion	1,084,783	7	154,969
Marshall	471,725	13	36,286
McDonough	46,389	54	859
McLean	154,943	2	77,471
Menard	403,896	14	28,849
Mercer	458,472	18	25,471
Montgomery	1,078,336	10	107,833
Morgan	2,698	2	1,349
Peoria	1,027,123	52	19,752
Perry	1,743,922	27	64,590
Putnam	268,710	2	134,355
Randolph	742,894	13	57,146
Rock Island	66,513	12	5,543
Saline	1,711,825	24	71,326
Sangamon	4,876,621	38	128,332
Schuyler	17,222	11	1,566
Scott	21,364	9	2,374
Shelby	143,308	11	13,028
Stark	25,480	11	2,316
St. Clair	4,435,070	79	56,140
Tazewell	216,901	11	19,718
Vermilion	3,019,934	59	51,185
Warren	14,110	15	941
Washington	68,768	2	34,384
White	7,243	1	7,243
Will	188,338	5	37,668
Williamson	5,266,452	46	114,488
Woodford	150,743	2	75,371

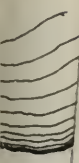




MAP NO. 2

BY A. BEMENT
1908.





LAKE

IM: HENRY

W

WINNEBAGO

W

W

W

W

W

W

W

W

W

W

W

W

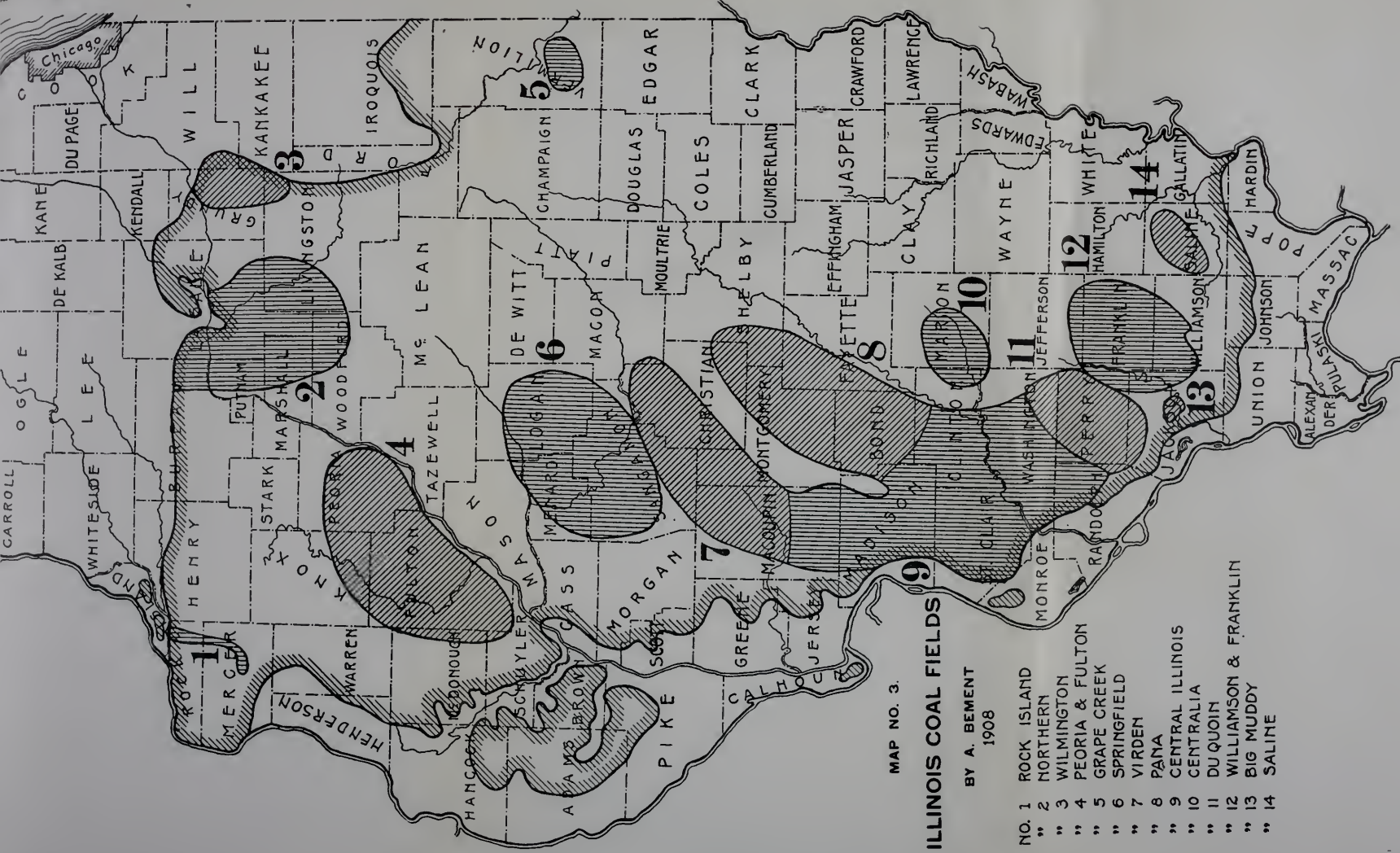
W

W

IRHIOLE COM HUE MIA

000 100 2





MAP NO. 3.

ILLINOIS COAL FIELDS

BY A. BEMENT
1908

- NO. 1 ROCK ISLAND
- " 2 NORTHERN
- " 3 WILMINGTON
- " 4 PEORIA & FULTON
- " 5 GRAPE CREEK
- " 6 SPRINGFIELD
- " 7 VIRDEN
- " 8 PANA
- " 9 CENTRAL ILLINOIS
- " 10 CENTRALIA
- " 11 DU QUOIN
- " 12 WILLIAMSON & FRANKLIN
- " 13 BIG MUDDY
- " 14 SALINE



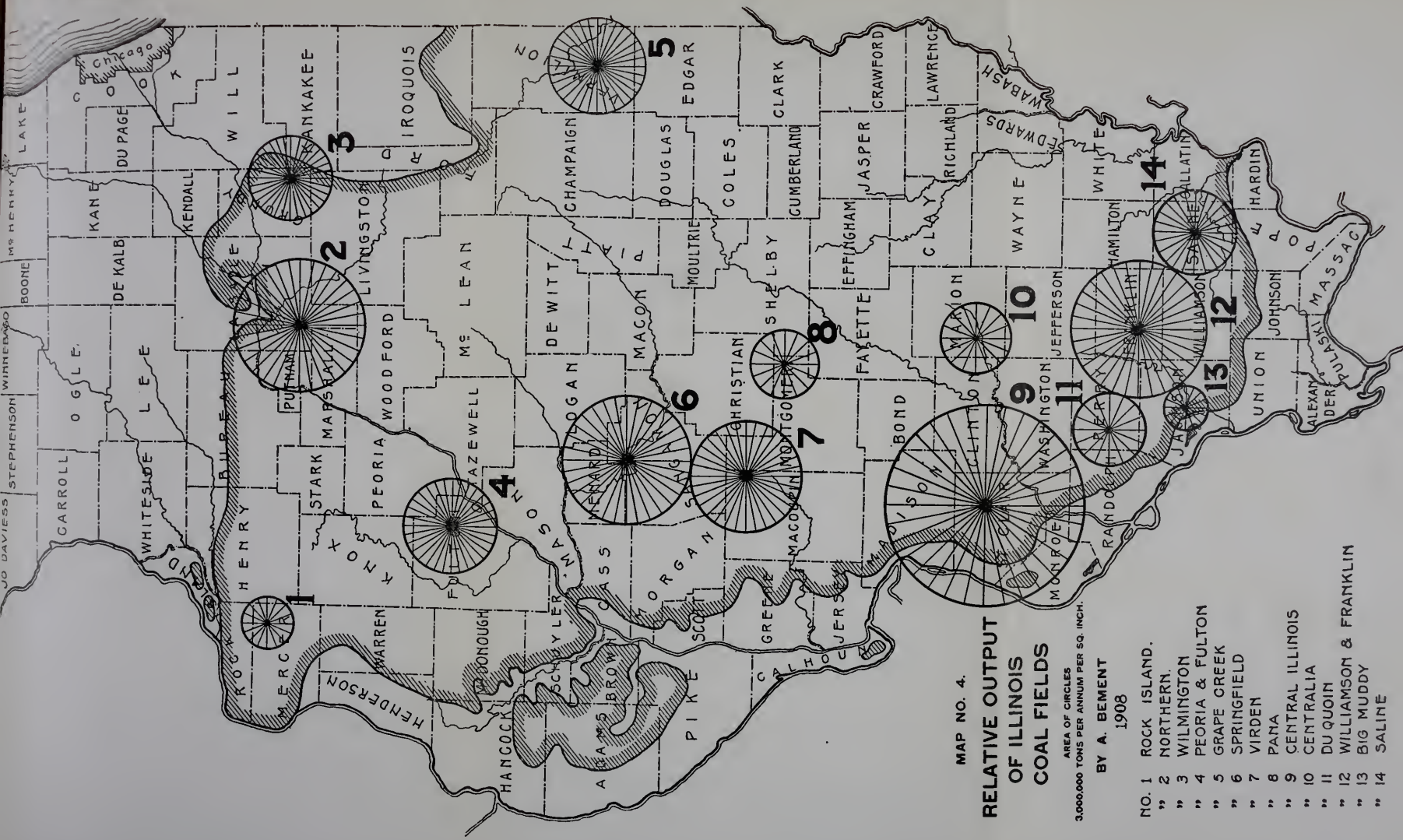


TABLE NO. 8.
CHEMICAL COMPOSITION OF SEAMS.

Seam.	Fields.	Moisture.	Ash in Dry Coal.	Moist Coal.	Heating Power per Pound in B. t. u.	
					Dry Coal.	Pure Coal.
No. 1	All fields	11.57	6.27	11,915	13,473	14,375
No. 2	Wilmington	15.34	5.87	11,316	13,367	14,201
No. 2	Northern	14.86	10.08	11,054	12,983	14,438
No. 5	Springfield	12.66	12.31	10,990	12,583	14,350
No. 5	Peoria and Fulton.....	14.67	15.10	10,381	12,166	14,330
No. 5	Saline	6.75	7.75	12,945	13,882	15,048
No. 6	All fields	14.38	11.69	10,774	12,584	14,250
No. 7	Williamson and Franklin.	9.65	12.16	11,508	12,737	14,500

TABLE NO. 9.

AVERAGE CHEMICAL COMPOSITION OF WASHED AND SIZED COAL AS RECEIVED
AT CHICAGO.

Williamson County.

No.	Moist Coal.			Dry Coal.	
	Moisture.	Ash.	B. t. u.	Ash.	B. t. u.
1	10.4	8.56	11,751	9.56	13,114
2	10.6	7.52	11,873	8.41	13,280
3	10.8	7.22	11,887	8.10	13,325
4	11.0	8.19	11,717	9.20	13,166
5	14.9	10.07	10,879	11.84	12,783

Central Illinois.

No.	Moist Coal.			Dry Coal.	
	Moisture.	Ash.	B. t. u.	Ash.	B. t. u.
1	12.50	8.28	11,026	9.46	12,601
2	12.70	7.74	11,072	8.87	12,683
3	15.00	7.99	10,718	9.40	12,610
4	15.30	8.68	10,580	10.25	12,491
5	17.50	9.47	10,164	11.48	12,320

When the fact is taken into consideration that Pocahontas coal reaching the Chicago market contains not less than 8 percent ash, it is apparent that this state produces a very good quality of fuel in these washed sizes. The screens used in its preparation are of the following sizes:—

Size	Screens	
	Over.	Through.
No. 1.....	1 $\frac{3}{4}$ inch	2 $\frac{1}{2}$ inch
No. 2.....	1 $\frac{1}{8}$ inch	1 $\frac{3}{4}$ inch.
No. 3.....	$\frac{3}{4}$ inch	1 $\frac{1}{8}$ inch
No. 4.....	$\frac{1}{4}$ inch	$\frac{3}{4}$ inch
No. 5.....		$\frac{1}{4}$ inch

The following brief statement will serve to illustrate the physical characteristics of the important coal seams:—

No. 1 is a very clean seam, having low ash content as shown by table of analyses.

No. 2 in the Wilmintgon Field is a very clean seam. In the

Northern Field there are some pyrites present. In the southern part of the state it is also a comparatively clean seam.

No. 5 in Fulton and Peoria County, contains a sulphur and other bands, which are separable in mining, and by proper preparation a good quality of fuel can be produced. In the Springfield District there are no sulphur formations, slate bands or other apparent impurities in the seam. The ash, however, is rather high and the coal may be considered to a slight extent as bony. In this respect it differs very much from the No. 6 seam just to the south, as it presents a clean black face, while the No. 6 seam has a slate and a number of sulphur bands, so that well prepared lump coal from No. 5 is not as low in ash as from other localities which carry the same total amount of ash in the seam. The leading characteristic of the seam is the presence of what are known locally as "horse backs" consisting of fissures in the coal seam extending from the roof to the floor, which when small are filled with material consolidated to a hard rock; when large are rather of clay formation. These shrinkage cracks range from a few inches to several feet in width. Properly speaking, these "horse backs" are not an impurity in the seam from the standpoint of coal preparation, because they exist vertically, and the seam is removed independently of them. The coal, however, is hard and strong, ships well and has a very favorable appearance. In Saline County the seam is very clean, the only impurity visible being occasional sulphur balls. The roof is generally very good, although in a portion of the field there is a thin parting lying between the coal and the rock above, that shoots down with and becomes broken up in the coal, requiring removal in loading.

No. 6 has a persistent slate band near the bottom of the seam, ranging usually from 1 to 2 inches in thickness. Above this are some well defined sulphur bands. The total ash in the seam for Illinois is not high, however, therefore it necessarily follows that the cleaner portion of the seam is quite low in ash, because a large percentage of it is present in the bands. For this reason a high quality of lump, egg or nut coal may be produced. Raw screenings from this seam contain approximately the same percentage of ash as those from No. 5 seam in the Springfield District.

Seam No. 7 is that which presents the greatest variation in quality. Like No. 6 there is a persistent slate band of from 1 to 2 inches thick near the bottom. The prevailing impurities are slate bands which are more or less irregular in thickness and presence, together with iron pyrites which occur as "sulphur balls," in an irregular formation called "cat faces" by the miners. There is a considerable variation in ash, ranging from 7 percent for the entire seam to quite high percentages in some territory prospected in Franklin County. In fact in this instance, slate bands were so persistent and thick as to make it unwise to attempt to operate. The sulphur content is also quite variable, there being spots in the seam where it is under one percent, ranging from this up to three and four percent. As an average, however, this seam is lower in sulphur than in any other

in the state, and in this respect is markedly different from that in the No. 6 seam in its northern and central areas. In fact, there are some spots which produce a coal that will make a very good grade of coke, well suited as a mixer with Pocahontas in the formation of a high grade product.

Map No. 3 shows segregated coal fields, and No. 4, the relative annual production in tons by shipping mines, for the fourteen various districts. There are excluded, however, a number of mines in territory not tributary to any of the recognized fields, but having, nevertheless, an annual output of about 1,500,000 tons, located mostly west of the Illinois River.

The following items which refer to the various fields are presented for purpose of identification by a number corresponding to that employed on the maps indicating the fields:

1. Rock Island Field. In the early days of mining in Illinois, Rock Island County produced quite an important percentage of the output, although from various small beds of coal in seam No. 1, which have now been largely exhausted. The main bed is indicated on the map as extending southward into Mercer County. The product is marketed in the towns of Davenport, Ia., and Rock Island and Moline, Ill. In quality the coal ranks high.

2. The Northern Field operates seam No. 2 which has a thickness generally of 3.5 feet. Mining is by the long wall method. The market for the product is very largely to the north and west, as the coal is of quite hard and strong character, therefore ships with a minimum amount of breakage, making it popular among country dealers. The principal product is lump coal and washed screenings, although in the past it has been lump and mine run; the finer sizes have little value in a raw state on account of the fire clay from the bottom and other dirt mixed with the coal. The screenings are now washed, and washed coal has become a product of importance, finding a market in Chicago and elsewhere. The cost of mining, however, is sufficiently high to prevent other product than washed screenings competing at Chicago with the thicker seams operated by the pillar and room method. Were it not for the high cost of mining, this and the Wilmington, or Field No. 3, operating the same seam, would have a much larger output. The seam lies at a depth of from 300 to 400 feet and is commonly known as the Third Vein, a name originating at the town of LaSalle, at which place former operations were in seam No. 7. This being the first to be worked was generally spoken of as the First Vein; later, shafts were sunk to No. 5 and called the Second Vein; still later, seam No. 2, being the third one operated, was called the Third Vein, and this appellation is quite commonly used to designate the seam operated by the long wall method in fields Nos. 2 and 3 in the northern part of the state. The town of Streator some years ago was the scene of very active mining operations, that were carried on in thick beds of coal, presumably seams 6 and 7, which in places came together, so that the rooms were driven as high as 12 feet in some cases. The thick bed, how-

ever, was of a limited area and has now been almost entirely worked out. Since the exhaustion of the thicker upper seams, shafts have been sunk to the No. 2.

3. The Wilmington Field was the principal source of supply of bituminous coal used in Chicago prior to the advent of the block coals from Indiana, the latter in large measure supplanting it until the thick seams to the south in Illinois took the lead. Thus Williamson County, some 300 miles away, can ship any grade of coal to Chicago which Grundy County cannot do, although at a distance of only 55 miles from Chicago, because of high cost of production, which overcomes the difference in freight rate. As in the Northern Field, seam No. 2, having a thickness of 3 feet, is operated by long wall method, and all of the fine coal is washed, finding ready market in Chicago, but the larger sizes, as with the Northern Field, are shipped principally to the north and west.

4. Fulton and Peoria Counties. This is a field operating by pillar and room method in what is called the No. 5 seam, having a thickness of approximately 4 feet. The product, which is mine run, lump, egg and raw screenings, finds market almost exclusively west of the Illinois River outside of the state, both to the north and west. This is a field which does not compete with the others of Illinois on account of high cost of production, due to the thin seam and other mining conditions.

5. The Grape Creek Field is the northernmost one producing cheap coal, wherein the No. 6 seam, having a thickness of about 8 feet, is operated by the pillar and room method. The product has found a ready market by a comparatively short haul, to the northern portion of Indiana and lower parts of Chicago; also to industries on the Belt Railway, the oil works of Whiting, Ind., and steel works of South Chicago being very large customers. The body of coal is a comparatively small one, but has been the most active field in Illinois, and while the character of the roof is such as to make mining expensive on account of the amount of timber required, the large output keeps down the cost of production to a low figure.

6. Springfield District. The bed of coal operated in the counties of Sangamon, Logan and Menard is known as No. 5. The seam is about 5 feet 10 inches thick, or approximately 6 feet, and the character of the roof is such as to allow the entire height of the coal to be mined, it not being necessary to leave any of the upper part of the seam for roof. Thus while a little thin to be classed in Illinois as thick coal, the fact that the entire height may be removed, together with the low mining rate, justifies such classification. The name, Springfield District, as often used, applies to a territory very much larger than shown on the map; in fact, extending down to as far as Macoupin, Montgomery and Christian counties, but in this southern territory the No. 6 seam is operated, and for this reason a separation is justifiable. The Springfield District is the northernmost field, next to that of Grape Creek, furnishing cheap coal at Chicago; in fact, it competes readily with other fields. The product is lump,

egg, mine run and raw screenings. This seam is rather high in ash, although other mining conditions are such as to insure that a minimum quantity of dirt becomes mixed with the coal, thus, notwithstanding the fact that ash is naturally rather high, the product is about the same in this respect as that of other localities.

7. The Virden Field operates seam No. 6 which has a thickness of from 7 to 8 feet, and owing to a shale parting ranging in thickness from 0 to 3 feet which lies immediately over the coal and under strong rock, it is the practice to leave up a portion of the top of the seam, forming a roof to hold the shale, although on main roads the top is brushed to the rock above, making very fine and permanent roadways. This condition, however, changes somewhat in the eastern part of the field, and the shale is replaced by a slate which allows the full height of the coal to be mined out, although the slate requires timbering. Lump, egg, mine run and raw screenings are produced. There are only two washers in the field, as it is a rather dry locality, and does not afford proper water supply for washing. This, like the Springfield District finds very ready market at Chicago, and is able to compete quite freely in the state.

8. The Pana Field operates in the No. 6 seam, which has a thickness of about 8 feet with good roof conditions. Lump and egg coal, mine run and washed and raw screenings are produced. The product finds ready entrance to Chicago via the Illinois Central and Chicago & Eastern Illinois Railways, but fields much further south in the No. 6 seam cannot readily reach Chicago.

9. Central Illinois Field includes Madison, Clinton, Washington, St. Clair and Randolph counties. All operations are in the No. 6 seam, having a thickness of from 7 to 8 feet. This is the territory immediately adjacent to St. Louis, Mo., and from which that city gets most of its fuel supply. In general, mining conditions are good, especially in St. Clair and Clinton counties. The roof in Madison County, however, requires much timbering. The product is principally lump, egg and mine run and screenings, the latter of which is shipped both raw and in washed condition. There are a large number of washers in the lower part of Macoupin and also in Madison County; in fact, this locality, together with Williamson County, are the most active points for coal washing in the state.

10. The Centralia Field is a very active locality with six mines operating in the No. 6 seam which lies at considerable depth, and the coal is of good quality.

11. The Duquoin Field is the southernmost extension of the great body of the No. 6 coal seam which comprises Districts 7, 8, 9, 10 and 11. Owing to the slightly better quality of the coal, distance from the general market, higher freight rates and other competitive conditions, it is separated in the classification from that of the Central Illinois Field, otherwise, the remarks concerning the other fields operating in this seam apply to it.

12. The Williamson and Franklin County Field is now, everything considered, the most important in the state. The coal seam

which averages 9 feet in thickness and ranges as far as known from 8 to 12, is overlain by a shale roof of such character that a portion of the seam is left up for a roof, which may readily be done on account of its great thickness. It is the most important district in the state for the production of prepared fuels, as a very large portion of the fine coal is washed and graded into five sizes. In fact, in some instances, there is no effort put forth to restrict the amount of fine coal made, because it is considered more desirable to produce the prepared sizes for market than lump or egg coal. Not all of the fine coal, however, is washed; a considerable percentage of high grade raw screenings is shipped. The field competes readily with the rest of the state. The quality of the coal is enough better than that from the No. 6 seam to overcome the difference in freight rate owing to the longer haul.

13. Big Muddy Field. The No. 2 seam is operated and has a thickness of 6 feet. It produces coal, which in the past has had a reputation of being the best in the state, but the bed, originally of very limited extent, is rapidly approaching exhaustion. This field enjoys a ready market.

14. The Saline County Field is the newest and in respect to quality of product, the most important in Illinois. Unlike the other principal coal fields in this state, the seam is not of a uniform thickness, but ranges from 4 to 8 feet. Mining conditions are also exceptionally favorable, a strong rock roof making it possible to drive very wide entries and room necks, so that cost for narrow work is reduced to a minimum. Until recently the field suffered for lack of transportation, the outlet being by way of the Cairo Division of the Big Four Railway, which was not suited to the economical transport of coal. This line, however, has been improved, since which time the percentage of increase has been much more rapid than that in any other coal field in the history of mining in Illinois. The field, however, does not compete to any great extent with other Illinois Fields, its coal having found a market of its own, largely owing to the favorable outlet furnished by its connecting railway.

BIBLIOGRAPHY.

Following is a list of papers on Illinois Coal and its utilization:

- Abbott, W. L. Some Characteristics of Coal as Affecting Performance with Steam Boilers. *Journal, Western Society of Engineers*, Vol. XI, p. 527.
- Ashley, George H. The Eastern Interior Coal Field. Twenty-Second Annual Report, U. S. Geological Survey, Part III, p. 271.
- Bain, H. Foster. Contributions to the Study of Coal (Introduction), Illinois State Geological Survey, Bulletin No. 8, p. 152.
- Bain, H. Foster. The Work of the State Geological Survey. *Journal, Western Society of Engineers*, Vol. XII, p. 233.
- Bain, H. Foster. Studies of Illinois Coals. *Transactions, American Institute of Mining Engineers*, Vol. XXXIX, p. 1099.
- Barker, Perry. The Occluded Gases in Illinois Coals. *Transactions, American Institute of Mining Engineers*, Vol. XXXIX, p. 1121.

- Bement, A. Distribution of the Coal Beds of the State. Illinois State Geological Survey, Bulletin No. 3, p. 19.
- Bement, A. Ash in Coal and Its Influence on the Value of Fuel. Illinois State Geological Survey, Bulletin No. 8, p. 205.
- Bement, A. The Necessity for a Geological Survey of Illinois. Journal, Western Society of Engineers, Vol. X, p. 131.
- Bement, A. Some Performance of Boilers with Chain Grate Stokers, with Suggestions for Improvement. Journal, Western Society of Engineers, Vol. IX, p. 44.
- Bement, A. The Commercial Value of Coal Mine Sampling. Transactions, American Institute of Mining Engineers, Vol. XXXVI, p. 834.
- Bement, A. The Sampling of Coal and Classification of Analytical Data. Journal, American Chemical Society, Vol. XXVIII, p. 632.
- Bement, A. The Suppression of Industrial Smoke with Particular Reference to Steam Boilers. Journal, Western Society of Engineers, Vol. XI, p. 693.
- Bement, A. The Testing of Coal. Journal, Western Society of Engineers, Vol. XI, p. 753.
- Bement, A. Some Results Due to Improvement in Boiler and Furnace Design. Journal, Western Society of Engineers, Vol. XIII, p. 209.
- Bement, A. Boiler and Setting. Improved Design for use with Bituminous Coal. Transactions, American Society of Mechanical Engineers, Vol. XXVIII, p. 509.
- Bement, A. Some Experiments to Determine the Amount of Volatile Matter in Coal. The Chemical Engineer, Vol. VI, p. 109.
- Bement, A. Heat Production and the Constituents of Coal. Engineering & Mining Journal, August 3, 1907, p. 222.
- Bement, A. Pure Coal as a Basis for the Comparison of Bituminous Coals. Transactions, American Institute of Mining Engineers, Vol. XXXIX.
- Bement, A. The Smokeless Combustion of Bituminous Coal. Transactions, American Institute of Mining Engineers, Vol. XXXIX, p. 1148.
- Breckenridge, L. P. Tests with Illinois Coals under Steam Boilers. Illinois State Geological Survey, Bulletin No. 3, p. 79.
- Breckenridge, L. P. Boiler Tests with Illinois Coals. Journal, Western Society of Engineers, Vol. VI, p. 220.
- Breckenridge, L. P. How to Burn Illinois Coal without Smoke. Engineering Experiment Station, University of Illinois, Bulletin No. 15.
- Breckenridge, L. P. Review of the U. S. Geological Survey Fuel Tests under Steam Boilers. Journal, Western Society of Engineers, Vol. XII, p. 285.
- Brinsmaid, W. The Amount of Inert Volatile in the Mineral Constituents of Coal. Journal of Industrial and Engineering Chemistry of the American Chemical Society, Vol. I, p. 65.
- Campbell, M. R. The Classification of Coals. Transactions, American Institute of Mining Engineers, Vol. XXXVI, p. 324.
- DeWolf, Frank W. Coal Investigations in the Saline-Gallatin Field, Illinois, and the Adjoining Area. Illinois State Geological Survey, Bulletin No. 8, p. 211.
- DeWolf, Frank W. Coal Investigations in Saline and Williamson Counties, Illinois. Illinois State Geological Survey, Bulletin No. 8, p. 230.
- DeWolf, Frank W. The Coal Resources of Illinois. Transactions, American Institute of Mining Engineers, Vol. XXXIX, p. 1103.
- Fernald, Robert Heywood. The Present Status of the Producer—Gas Power Plant in the United States. Journal, Western Society of Engineers, Vol. XII, p. 551.

- Francis, C. K. The Modification of Coal by Low Temperature Distillation. Transactions, American Institute of Mining Engineers, Vol. XXXIX, p. 1158.
- Frazer, Persifor. The Classification of Coals. Transactions, American Institute of Mining Engineers, Vol. XXXVI, p. 825.
- Leverett, Frank. The Illinois Glacial Lobe. U. S. Geological Survey, Monograph 38.
- Lindgren, J. M. The Sampling and Analysis of Illinois Coals. Transactions, American Institute of Mining Engineers, Vol. XXXIX, p. 1113.
- McFarland, H. B. Test of a Small Suction Gas Producer Plant. Journal, Western Society of Engineers, Vol. XIII, p. 173.
- Parr, S. W. Composition and Character of Illinois Coals. Illinois State Geological Survey, Bulletin No. 3, p. 27.
- Parr, S. W., and Others. Chemical Analysis of Certain Coals. Illinois State Geological Survey, Bulletin No. 4, p. 188.
- Parr, S. W. Anthracizing of Bituminous Coal. Illinois State Geological Survey, Bulletin No. 4, p. 196.
- Parr, S. W., & W. F. Wheeler. An Initial Coal Substance having a Constant Thermal Value. Illinois State Geological Survey, Bulletin No. 8, p. 154.
- Parr, S. W., & W. F. Wheeler. Alterations of the Composition of Coal during Ordinary Laboratory Storage. Illinois State Geological Survey, Bulletin No. 8, p. 167.
- Parr, S. W., & C. K. Francis. Artificial Modification of the Composition of Coal. Illinois State Geological Survey, Bulletin No. 8, p. 176.
- Parr, S. W., & N. D. Hamilton. The Weathering of Coal. Illinois State Geological Survey, Bulletin No. 8, p. 196.
- Parr, S. W. Heat Production and the Constituents of Coal. Engineering and Mining Journal, June 29, 1907, p. 1242.
- Ray, W. T., & Henry Kreisinger. The Nature of True Boiler Efficiency. Journal, Western Society of Engineers, Vol. XII, p. 661.
- Rice, George S. Mining Wastes and Mining Costs in Illinois. Transactions, American Institute of Mining Engineers, Vol. XXXIX, p. 1127.
- Snodgrass, J. M. Use of Illinois Coal for Domestic Purposes. American Institute of Mining Engineers, Vol. XXXIX, p. 1142.
- Talbot, A. N. Compression Tests of Illinois Coal. Illinois State Geological Survey, Bulletin No. 4, p. 198.
- Udden, J. A., and Others. Illinois Coal Field. Report, Illinois Board of Commissioners, World's Columbian Exposition, 1893.
- Udden, J. A. The Delafield Drill Core. Illinois State Geological Survey, Bulletin No. 4, p. 203.
- Udden, J. A., & F. W. DeWolf. Notes on the Belleville-Breese Area. Illinois State Geological Survey, Bulletin No. 8, p. 246.
- Udden, J. A. Defects in Coal No. 5 at Peoria. Illinois State Geological Survey, Bulletin No. 8, p. 255.
- Weller, Stuart. Preliminary Geological Map of Illinois. Illinois State Geological Survey, Bulletin No. 1, p. 9.
- Weller, Stuart. Notes on the Geology of Southern Calhoun County. Illinois State Geological Survey Bulletin No. 4, p. 219.
- Weller, Stuart. The Geological Map of Illinois (Second Edition). Bulletin No. 6.
- Wheeler, W. F. The Weathering of Coal. Transactions, American Institute of Mining Engineers, Vol. XXXIX, p. 1153.
- Wheeler, W. F. Pure Coal as a Basis for the Comparison of Bituminous Coals. Transactions, American Institute of Mining Engineers, Vol. XXXVIII, p. 621.
- White, David. Report of the Field Work in the Coal District of the State. Illinois State Geological Survey, Bulletin No. 4, p. 201.

DISCUSSION.

President Allen: One of the principal duties of our Society is to bring up for presentation and discussion the commercial and engineering problems of the west, and Mr. Bement's paper, which treats so thoroughly and well of the coal resources of this state, will be of extreme interest and value to all engineers. The coal supply of any district is very intimately connected with its industrial supremacy. We are not favored, in this part of the world, with very much natural water-power and we have to depend for motive-power largely on our fuel supply, of which coal is of course the principal factor. The industrial supremacy of Illinois depends very largely today upon the existence of its coal field, and we have now come to the point where the first exploitation has been made, where we have got to consider these things scientifically, and with a view of conserving our supply, working it economically and scientifically.

This paper ought to call out a good deal of discussion among the geologists, among the users of coal, and among the miners of coal. It ought to form the basis of better classification of coal of different fields and more scientific use of the coals in these fields.

Mr. Gordon Buchanan: In reading over Mr. Bement's paper, the point that appealed to me most was the question of the causes leading up to the present reckless and wasteful methods of mining. Recent numerous accidents have led the Illinois Coal Operators' Association to appoint a mine accident committee, of which I happen to be secretary. Mr. Carl Scholz, a mining engineer, is chairman of that committee, which is made up of one member from each of the nine districts of Illinois. The purpose of the committee is to investigate accidents and endeavor to get at the reasons and the remedies. This has led us to look into the question of the production of coal from a different point of view than as ordinary operators. Recently, as some of you know, there was a coal conference at Urbana, at which Dr. Holmes, Mr. George S. Rice and Mr. R. Y. Williams, of the United States Geological Survey, with Dr. Bain and Mr. F. W. DeWolf, of the State Geological Survey, were present, representing the miners, consumers, and operators. I think there is no question in the minds of all of you as to the desirability of preventing the waste of the natural resources of the state, among the greatest of which is coal.

The value of the mineral output of the state, according to the State Geological Survey, for 1907, was estimated at \$152,000,000, of which some 54,000,000 tons of coal was valued at a trifle over \$54,000,000. The output in tons per man is rapidly increasing. What is the reason for that? One is that since we "let down the bars" some years ago and permitted the mine-run system to become a factor in the state, the entire energy of every miner in the state—a greater portion of which was heretofore devoted to safe-guarding of mines—has been largely and almost exclusively devoted towards an increased tonnage per man. The miners today do not care how that coal is produced, and the result is that the coal is often mined in such a way that a very

large proportion cannot be economically burned—at least under the majority of boilers now in operation. We have smoke preventive boards as a consequence.

The rapid increase in the reckless and unintelligent use of explosives has been the direct cause—at least largely—of the increase in fatal accidents and damage to property. At present the Leiter properties are sealed up and practically abandoned, and no one knows when they can be opened up again. A very large investment, perhaps, and possibly a large coal field, has been lost.

The recent explosions and fires in Franklin county have led a number of property owners to approach Mr. Scholz in an effort to have him dispose of the property. This fact is giving the state a bad name, discouraging investments, etc. The conditions that exist today through ignorance among miners, their disregard of authority, and the danger of setting fire to valuable coal fields, especially in Franklin county where the coal has a tendency to take fire easily, is one that ought to be guarded against. In fact, the recklessness in the use of explosives has reached such a point that the men are afraid to remain in the mines when the explosion takes place.

An electrical device is now on the market which it is claimed will fire the shots as prepared in the mine. But those of us who have examined the machine are confident that it is too complicated and that it will not be wise to use it, because in many mines it is necessary to examine the mine immediately following the shots, in order to extinguish fires which frequently take place. The machine fires a shot every minute, and there are many mines where there are 200 or 300 shots fired each day; if we say that half of those shots were fired—150 shots—and that the next one set fire to the coal, that would mean 150 minutes at least, before anyone could go into the mine and see whether there was a fire. With a current of 150,000 to 200,000 cubic feet of air per minute you can readily see what would happen to that mine if a fire had a start of 150 minutes. I merely cite this illustration to show what the mining industry has to contend with today. We feel that it is a dangerous situation, and it is one in which we need the public's help.

Another reason for accidents is the lack of discipline. There are in the mines today, men that five or ten years ago would not have been allowed on the premises. The rapid increase in the number of mines and the fact that the labor organizations have been able to practically tie the hands of the operators as far as increased number of laborers coming into the state is concerned, has compelled us to employ an ignorant and cheap class of workmen. We have a good many operators who know practically nothing about the mining business, and who are conducting mining operations in a reckless and ignorant way. Many of them happened to have land under which coal existed, and organized companies, expecting to get rich suddenly.

The state is attempting to educate men, through the State Mining Board, to act as mine examiners and mine managers, but the number

of men available for that purpose is quite limited. Although the United States is the second coal-producing country in the world, and Illinois is the second state in the production of coal, there is only one school in the country (in Oklahoma) where coal mine engineering is taught to any great extent.

At the recent coal conference in Urbana, the report of what the United States Geological Survey is doing towards the investigation of explosions and explosives was partially given out. The fact was borne in upon all of us that there is an absence of exact knowledge relating to coal mining. There is no doubt but that we are wasting our resources; there is no doubt but that the state is being injured through the damage to property interests by the reckless use of explosives. After some discussion, a resolution was offered by Mr. Carl Scholz, seconded by myself, which paved the way for a committee to go before the State Legislature and request the establishment of a school of mining engineering in the State University. Mr. Scholz and I were authorized to appoint the committee, which was intended to represent the interests of the consumers, manufacturers, miners, state mine inspectors, and the operators, so that it will be practically an impartial body. It seems to me that such an institution is one in which every citizen in the state is vitally interested. It certainly will pave the way to a conservation of one of the greatest natural resources we have in the state.

The present status of the movement is that bills have been introduced in the State Legislature and are now in the hands of the appropriation committee, and it seems to me that it would be a wise move, if you see fit, for you to endorse that movement. A modest sum has been asked, to start it, which will probably not be enough to maintain it in the future—\$15,000—but it is thought that this is enough to organize on. The plan is to have a course at the University for such of the miners as feel able to attend the school, and to educate young men for official positions, the idea being that through them and the corps of instructors, investigations would be made into the causes of accidents, with a view of improving the processes of mining. This would tend to conserve the resources, and thereby benefit directly or indirectly everybody in the state. Anything which can be done by engineers, miners, or the general public, to improve the present mining methods should be done.

The mining industry is badly handicapped by unwise legislation in Illinois. As an example of what has been done, at the last Legislature a law was passed, that no operator should employ a man who did not hold a certificate of competency. This law provided that a board of three miners should be appointed by the Circuit Judge in each county, who should pass on the miner's qualification. The plea in connection with the introduction of the law was, that so many reckless men existed among the ranks of the men, that many of the better miners were becoming afraid to go into the mines for fear they would be killed. I have yet to hear of a miner, good or bad, who did not qualify.

We mine operators are to blame partially for the conditions that exist, because we have not taken the public into our confidence. We believe that the time has arrived—in fact it arrived a long time ago—when all of us should take an active interest in the existing conditions, especially in coal mining in Illinois, because this all reacts directly or indirectly on you or those whom you represent. A needless burden is placed upon an investor when the men are permitted to dictate how things shall be done in the mine, for the miners then become careless of discipline and are not willing to be directed. If such practice is continued, it will eventually rob the state of a very large proportion of its resources, through fires, etc.

President Allen: Those of us who have read the "Confessions of a Railroad Signal Man," will recognize that the problem of the coal operators is the same one that the railroad operators are now trying to meet—interference of labor organizations and unintelligent legislation. It is the experience of the world that it takes accidents and disasters to awaken the public, but that when public sentiment has been once aroused, it moves with irresistible force. So it seems from the record as though public sentiment were in a fair way towards being aroused, and our Society may perhaps be able to contribute its influence towards the proper settlement of the relations between the miner and the operator.

Mr. J. K. Dering: In listening to the discussion this evening, I was impressed with the remark that it has been predicted that the supply of coal will be exhausted in sixty or seventy years. Our engineers have been in the East lately, and came back with information about how there they produce coal. They seem to be making a much larger extraction than we are, and this has set us to thinking. Many times we have thought that the time is not far distant when it is going to become necessary to pass some laws that will compel us to take out more coal and stop the waste. We have been obliged, on account of competition and over-production of coal in Illinois, to pay more attention in undertaking to get a small profit out of our mining industry than we have to conserving the supply. But I hope we shall be able, with your aid, to make some progress along that line.

Mr. Bement has a very high place in the minds of all coal men in the west, especially in Chicago, and we consider that he has done a great deal for us, in the way of preparing maps, etc. We consult his coal data daily. Possibly other men have done similar work, but he is the one man whose work I am familiar with.

Mr. Paul P. Bird: I think that the Western Society of Engineers is to be congratulated because of the paper that Mr. Bement has presented tonight. Such a paper entails a vast amount of time and labor. It is very desirable that data of this sort be collected and classified and from time to time presented to us in this form.

To a layman I think the most interesting feature of the paper is that portion touching on the conservation of the natural resources. During the last year we have heard a great deal on this subject.

President Roosevelt and Gifford Pinchot have taken a great deal of interest in this matter and have started the ball rolling. The outlook is hopeful when societies of this sort discuss these questions, when we are considering a mining school at our State University, when we have such meetings as was recently held at the University of Illinois—*The First State Fuel Conference*—and when so much attention is being paid to the proper methods of burning coal economically and without smoke; all these things show that we are all working toward the same end and that—the conservation of the fuel resources of our country. I think the author of this paper is doing a very large share of this work.

Mr. C. W. Naylor, M.W.S.E.: In reading over the paper I notice the author alludes to the Pana district and the Big Muddy district, While we are fairly well familiar with the maps it occurred to me to suggest, for the author's consideration, that he possibly include with the name of the county that of the town, which latter is not shown on the maps.

Mr. Warren R. Roberts, M.W.S.E.: I wish to add my testimony as to the value of this paper. I read it carefully, thinking I would have a good many questions to ask the author, but found he answered most of them before I had completed the paper.

On page 310 the author refers to a deep seam of coal discovered by boring at Lovington, Ill. To complete this record, I think it might be well to add that the shaft is now down to coal and that 8 ft. 2 in. of coal was found at approximately 900 ft. depth. The two seams do not run together without the intervening rock, as the boring had seemed to indicate, but the seams were approximately the same as were found at Assumption, viz.: 2 ft. of black slate above the 8 ft. 2 in. of coal, and then 12 ft. of limestone. Nothing was said as to whether the upper seam was immediately above the seam of 12 ft. of limestone or not, but mention was made that there was some 15 or 20 ft. distance between the seams of coal.

Mr. W. L. Abbott, M.W.S.E.: The remarks that I will make, are along the line of what Mr. Buchanan has said in regard to the miners having the operators quite tightly sewed up. Now, I do not think that anyone knows today, better than the operators, that they have what was coming to them.

Personally I know nothing about this matter, but different operators have told me that before the miners were organized, their hours of work were long, their conditions of labor were very disagreeable, they were compelled to trade at the company's store, the mining rate was irregular and always low, and that while the miners themselves were loading cars way down below in the pit, the company's weigh-master was up on top weighing this coal in very long tons on uncertified scales. Finally the miners organized, and then strikes occurred first in one district and then in another, with the usual accompaniment of fights.

The situation even then was not beyond easy control, but when the

operators of one district found that a strike in a competitive district made business good for *them*, they contributed to the strike fund to keep the strike going. After the miners won their fight in the first district they called a strike in another district, and the operators in the first district would return the compliment and contribute to the strike fund in the other district. So it took but a short time, with the kind assistance of the operators, to get the miners fully organized.

The last nail to thoroughly box up the operators, was driven when the operators were forced to agree to employ none but union men and to collect from the miners' wages the union dues and turn them over to the organization. At this time also was the change from the lump coal basis to the mine-run basis. The effect of that is seen by the curve in Mr. Bement's paper. The amount of powder per ton of coal is being doubled. You may not all understand what this means. Formerly a miner was paid by the ton of lump coal, which he mined and hoisted out. All the screenings which he mined he was not given credit for. Now he is paid for all the coal which he mines, be it fine or lump. Therefore, the miner has no interest in seeing that he does not break up the coal any more than possible. Formerly he would lie down on his side and with a short pick-ax under-cut the wall of coal, reaching in as far as he could, four or five feet, then drive wedges in at the top of the ledge and break off what he had under-cut. In that way there would be very little screenings. He used some powder with the wedging, and perhaps sometimes he would not use any powder. Now the miner does not care how much fine coal he gets, because coal is coal to him. He does not under-cut the coal in many cases, but will drill several holes from five to six feet deep, put in a whole lot of powder, and then leave the mine while the shots are being fired by someone else. If too much powder has been put in, when that shot is fired it does what they call "blow out," and instead of extending its force deep in the ledge it will blow out like a cannon, a great cloud of fine coal dust, which is ignited from the powder flame and results in a disastrous explosion. With the increased use of the powder we have this shattering of the coal, which is gradually increasing the fine coal.

With the organization of the miners, naturally the mining rate has gone up, and competition is so severe among the different mines that the profit on a ton of coal is very small—a few cents only. If you ask any operator who is selling coal for ninety cents a ton what it costs him, he will assure you it costs him ninety-five to get it out, but the difference of five cents is probably on the other side. The profit in mining is probably five or ten cents, but that is very small and can easily be lost. The fact that coal in the seam costs less than one cent a ton, while the labor necessary to get it out costs from fifty to seventy-five cents, naturally leads to wasteful methods of mining. For example, in the southern part of Illinois, where the coal seam is very thick, the miners go into the seam like vandals, carve out what they can get easiest, and leave up two or three feet of coal. It will

cost the operator two or three cents per ton more to get out the coal which is at the top of the vein than it will to get out that at the bottom; therefore, he leaves it, and that coal, as well as the coal in the pillars, which constitutes about one-third of the seam, is left there for all time.

If there were laws to compel the mining to be done so that the miner would have to begin at the outer edge of the field and work in toward the shaft, all the coal could be gotten. As it is now, he has to leave 30 to 50 per cent of it. The operators realize all this and I have no doubt they will be glad to prevent that waste, if possible, but if any one operator or any dozen operators would try to prevent that waste, they would surely fail, because the cost of mining would be five or ten cents higher than mines which would not operate that way. No one state could regulate that matter. If Illinois should do it, Indiana and Ohio and other states would compete in this market and our mines could not operate. It would require a national law to regulate the mining so that the present wasteful methods would be discontinued.

I wish to say a word about Mr. Bement's work in coal. I do not believe that many appreciate the great value which his work has been to the coal interests of the state. Take, for instance, those four maps he presents, and which have appeared in substance many times before. Maps are usually made from maps, but in this case the information which is presented never appeared before he presented it—certainly not with boundaries defined as he has defined them. This work represents an immense amount of labor. Mr. Bement has traveled all over the state many times, in an investigation of all the principal mining districts, and this paper is the result of a great deal of study, much of the information never before having been published.

*Mr. Walter T. Ray, *M.W.S.E., (U. S. Geological Survey):* The substance of this paper interests me in a general way only, but I nevertheless feel that it is excellent in quality and unusually complete. Some things in this paper give me a "conservation" feeling, and it is certainly an important feeling to have, and rather popular just now; possibly overly so with coal. I am reminded of a remark of Mr. W. L. Abbott that it would be far better for the world if every ton of coal were out of the ground and burned, because carbon is worth more in cellulose (lumber) than in coal; he said perhaps the law should compel every mine operator to set fire to worked-out mines after establishing proper precautions, so our descendants could get in the form of vegetation the third of the coal now left in the ground. I think the deplorable feature of much past mining has been such a procedure as left not only a third of the worked vein in the mine, but, worse yet, disjointed and ruined almost past profitable recovery some thin seams above. Such thin seams are thus rendered largely incapable of being burned out by Mr. Abbott's method.

*The present discussor wishes it understood that he presents these remarks as a member of the Society, and that his employer, the United States Geological Survey, is in no wise responsible for any opinions expressed.

Conservation of coal is undoubtedly an important matter; but after all to my mind the deplorable fact is that its approaching exhaustion will bring on earlier the time when an enormous amount of labor and capital must be forever sunk in efforts to devise a substitute; I believe that the average man seldom realizes that the gross world-wide cost of finding some new method is enormous. Sometimes I cannot but think of the story of the ancient whale fisher who had just towed to shore an especially large whale; when the tide receded he sat upon his prize and lamented that soon the whales would be extinct, and then the world would be in darkness; but, he said, he had a family to support and he hoped by the time no more whale oil was obtainable his descendants would have grown able to see in the dark.

I put forward here one suggestion very tentatively for burning some coal left in mines in such a way as to get power out of the process. Often it is extremely difficult to extinguish a mine fire. This suggests the possibility of blowing air down one shaft and taking out thin producer-gas from another; how much carbon monoxide there would be in the exit gas is beyond guessing and I have never seen any data; I simply offer the suggestion as one worth contemplation, for burning the pillar coal out of worked-out mines in such a way as to use the mine as a huge gas producer. Of course, careful study would have to be made of the roof, walls, etc., so as to make sure that no carbon monoxide (CO) would get into other mines or into houses above. If necessary the whole mine could be worked slightly below atmospheric pressure.

I shall make no criticism or additions, but rather show one of Mr. Bement's plottings (Fig. 3) on the logarithmic scale vertically, and add to it on the same chart (my Fig. A) plottings of the total number of short tons of bituminous coal mined in the United States since 1880, and of the total "spot value" of this same bituminous coal. ("Spot value" is a term used by the U. S. Geological Survey to mean the value at the mine.)

Possibly some members will appreciate an explanation of the properties of the logarithmic scale. In my figures A and B submitted herewith the vertical spaces were taken directly off a slide rule. If the reader will measure the distance from 1 at the very bottom of the chart to the 2 above it, he will find it exactly the same as the distance from 2 to 4, from 5 to the 1 (10) above, or from any 3 to the next 6 above. In this scale 2 may stand for 0.2 or 2.0 or 20 or 2,000,000, etc. It will have been realized by this time that on this scale equal vertical rises or declines represent equal percentage increases or decreases.

Fig. A gives the curve of Mr. Bement's Fig. 3—that is, the output in millions of tons of Illinois coal plotted as curve A. Through this jagged line I have put a light dotted straight line; after drawing it I found on inspection that it indicated as nearly as possible a 100 per cent increase per decade since 1881, on the assumption that the figures for 1881 are incomplete. If the reader will look at Mr. Bement's Fig. 3 he will notice a slight dip beginning in 1883 and a large dip in 1893. Curve A of my Fig. A shows these dips to have

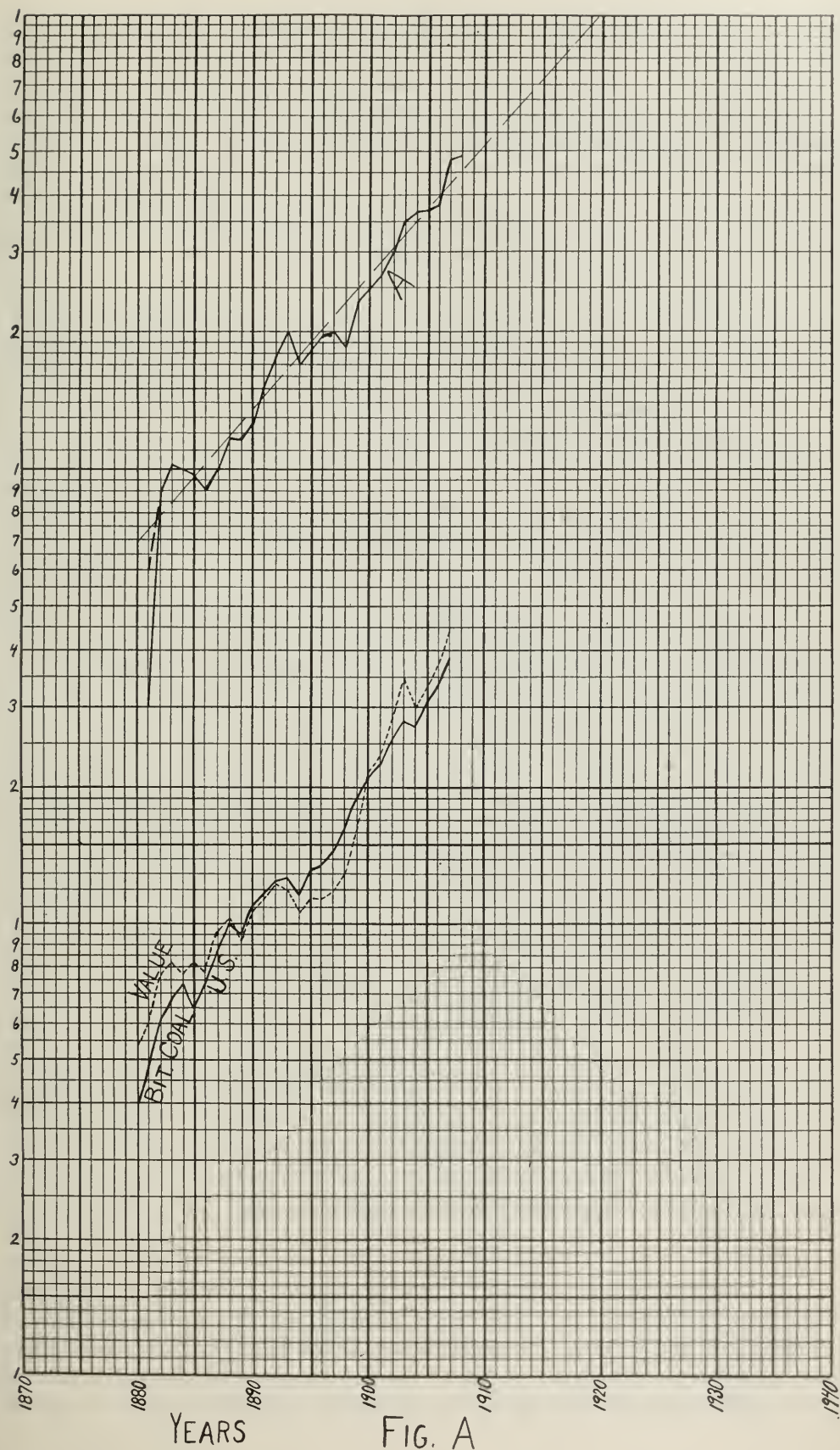
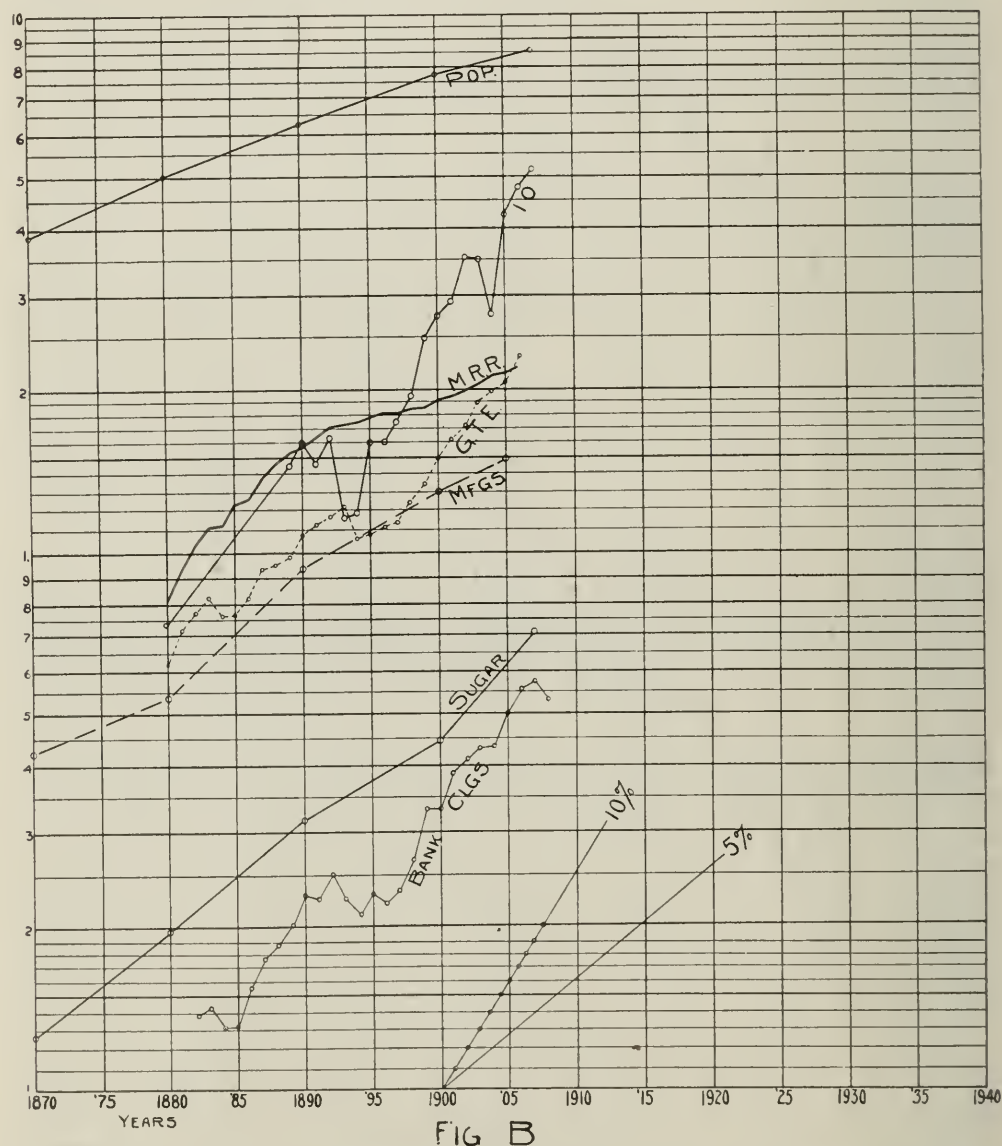


FIG. A

been of equal percentages, and therefore probably of equal severity. Mr. Bement's curve shows a very sharp rise from '06 to '07, mine only an ordinary one; that is, the rate of increase was nothing exceptional.

The reader will notice the suspiciously low value of the Illinois production for 1881, brought out especially by the logarithmic plotting. When Mr. Bement saw this, he set on foot an independent investigation and found that it was really about 6,000,000 tons. I have shown this value by the dotted line; it falls quite close to the broken straight line drawn through the tonnage curve.



As a matter of comparison I have also plotted on Fig. A the total short tons of bituminous coal mined in the United States and the spot value of this same coal, as stated above. One is thus enabled to study price changes. Perhaps the fact that the price of coal has increased more rapidly than the production during the past few years is due to

the falling value of gold. The general trend of the curve of the United States production of bituminous coal is at the rate of about 100 per cent increase per decade. Both my figures A and B extend out to the year 1940 so that readers may in after years plot productions on them. If the lines fall the rates of increase of production will be decreasing; if they rise the rates of increase of production will be increasing.

Mr. Bement says that under present commercial mining conditions only 16 per cent of the 201 billion tons of coal are to be had from Illinois. (If I understand him right this is 32,160,000,000 tons.) Curve A of Fig. A, shows a 100 per cent increase per decade. How many decades will it take, then, to exhaust this coal, at the present rate of increase? In 1909 the output will be about 50,000,000 tons. We may restate a compound interest formula thus:

$$\text{Number of decades} = \frac{\log. 32,160,000,000 - \log. 50,000,000}{\log (1+1.00)}$$

Solving this, we obtain 9.3 decades, that is, about the year 2003. This is alarming, if true. Every citizen of Illinois as well as of Pittsburgh should "sit up and take notice," and begin to study mining and substitutes for coal. I wish it especially understood that this calculation is only widely approximate and subject to withdrawal.

Fig. B is presented as of general interest. The top curve marked "Pop." is the population of the United States. The next one, marked "I. O." is the *long* tons of iron ore produced in the United States. This curve is more alarming to me than are the coal curves, because coal can be recovered in valuable vegetation, but iron rust is largely gone forever; this curves rate of rise is also exceptionally rapid. The curve marked "M. R. R." is the total miles of railroad operated in the United States. The curve marked "G. T. E." is the gross traffic earnings of all the railroads of the United States. The curve marked "Mfgs." is the total value of all the manufactures of the United States. "Sugar" is the total pounds of sugar consumed in the United States. "Bank clgs." is for the whole United States outside of New York City. "10%" is the amount of one dollar at various times when at 10% compound interest, compounded annually; "5%" is the same at 5% compounded annually.

Dr. I. C. White, (Morgantown, W. Va.): I observe that Mr. Bement has reduced Mr. Campbell's estimate for the coal in Illinois by approximately 40,000,000,000 tons, and about the only criticism I have to offer is, that I think his estimate is probably still too high, since when more thorough exploitations have been carried over the entire field, it will probably be found that there are many areas where the thick coal thins down greatly or disappears entirely, just as that described as existing in the vicinity of Streator.

Mr. Frank W. De Wolf, (Acting Director, State Geological Survey, Urbana, Ill.): It has been a pleasure to read and listen to Mr. Bement's paper since several of its phases have been studied by members of the State Survey, and this is a helpful summary of our exist-

ing knowledge about Illinois coals. There are several statements and suggestions which I hope to discuss further with Mr. Bement, but which are not of sufficient general interest to be mentioned here. In the Geological Survey studies, frequent consultations with Mr. Bement about the work have always proved helpful.

In referring to the stratigraphy of the coal fields a word of appreciation is due the pioneer work of A. H. Worthen, the former State Geologist. Although, as Mr. Bement has remarked, Worthen did not contribute as much information of a practical kind as might be expected, yet the fundamental work accomplished doubtless laid the foundation for much that has been done by Geologists and Engineers since his time. The division of the Coal Measures into two formations along the line of the Carlinville limestone has since proved unfortunate because that limestone itself, is traced only with great difficulty and accurate mapping of the two formations is therefore nearly impossible; in addition, this classification places in the Lower Coal Measures the basal sandstones which differ greatly from the productive Coal Measures just overlying. A more natural arrangement, in the writer's estimation, is that suggested in a recent paper, * in which the Coal Measures are divided into three formations, as follows:

(1) A basal portion composed chiefly of massive sandstones and barren of important coals. This is 650 ft. thick in the southern counties, but wedges out to the West and North.

(2) A second division extending from the floor of coal No. 2 to the roof of the blue band coal, locally called No. 6 or 7. This division includes all our important coal and it varies from 200 to 300 feet or more in thickness.

(3) The third and topmost division contains no important coals and is dominated by shales and other beds which are traced with difficulty. This formation in its greatest development is 1,200 ft. or more in thickness.

Mr. Bement has presented notes on each of the important coals and has mentioned some of the doubtful correlations. Recent work of the Survey has shown that the coals below No. 2 are somewhat pockety in their distribution, but that beginning with No. 2 and extending upward they are much more regular. The No. 2 of the La Salle region exists in the western counties also and is traceable to Murphysboro on the south. This correlation, by the way, was suggested in the old Worthen reports and has recently been verified. Coal No. 5 is one bed in Sangamon, Logan, Fulton and Peoria counties. Its correlation with Saline county No. 5 has not yet been definitely established. The No. 6 seam of Henry, Stark and other northern counties is regarded by members of the Survey as identical with

*The coal resources of Illinois by Frank W. DeWolf. Transactions of the American Institute of Mining Engineers, Volume 39, page 1103.

the seam which extends from Chatham southward through the Virden Mt. Olive and Belleville districts to Duquoin, and eastward into Williamson, Franklin and Saline counties, where it has formerly been known as No. 7. This correlation is based on several lines of evidence. The coal along this entire extent has a tendency to show a blue band of shale or sulphur from one to two feet above the floor. It also is characterized by a limestone roof rock which carries a minute fossil *Fusilina*, resembling a wheat grain, and so far as known, limited to this particular horizon. With reference to the Duquoin area, where there has long been uncertainty about the relations of the coals: A large collection of drill records now being studied by the Survey, traces the coal, step by step from the western part of Duquoin eastward and South into Franklin, Williamson and Saline counties. I regret that some of these logs are now away from the office, and that it is not practicable to present them here. Another region, where the correlation has long been uncertain, is the Danville-Grape Creek area. Fossils identified during the past season by Mr. David White indicate that the Grape Creek, or No. 6, is identical with the No. 6 seam of southern and western counties, and that the Danville, or No. 7, may be the same as a coal in Peoria county, which is locally known by the same number.

TABLE X.

Analysis of Face Samples from Southern Counties.
State Geographical Survey.

	Lab. No.	Moisture	Ash Dry Coal	B. t. u.		
				B. t. u. Moist Coal	Dry Coal	Ash Water, and Sulphur free
Group A.						
Coulterville to Duquoin along I. C. Ry.	1592	10.49	12.17	11064	12361	14285
	1835	10.55	12.12	11084	12393	14353
	1591	11.11	15.89	10542	11859	14354
	1614	10.37	13.92	11018	12293	14511
	1615	9.87	13.86	11051	12261	14422
Average		10.48	13.59	10952	12233	14385
Group B.						
Perry County east of Duquoin	421	9.31	14.71	11047	12181	14338
	1523	11.03	12.63	11079	12453	14308
	1810	10.13	10.29	11633	12945	14473
	419	11.19	10.11	11531	12985	14480
Average		10.41	11.93	11322	12641	14400
Group C.						
Eastern part of Jackson County	1800	9.14	10.22	11786	12970	14484
	1799	7.81	13.20	11662	12650	14804
Average		8.47	11.71	11724	12810	14644
Group D.						
Northwest corner of Williamson County	460	9.50	10.13	11836	13078	14615
	1917	8.86	9.65	11942	13103	14563
Average		9.18	9.89	11889	13090	14589

Mr. Bement's deductions about the coal resources of the State and the available tonnage are especially interesting to me. Estimates of the original quantity of coal are always to be regarded as extremely

uncertain, and it would seem desirable that they should be conservative rather than otherwise. In the figures previously published by Mr. R. Campbell, and those by the writer, the computation has been on a different basis from that used by Mr. Bement, and in part this explains the wide latitude in the estimates. Mr. Campbell's figures include coal measuring 20 inches and over; those by the writer include coals 24 inches and more; while Mr. Bement's estimate includes all coals measuring over 12 inches.

In discussing the thick and thin seams of the State, Mr. Bement has shown clearly the migration of the center of production into the region of thick coals and has implied that the coal wealth of the State is practically confined to the thick deposits, for he says that: "The 25% of coal produced from the thin and medium thick seams is shipped away and the State is dependent upon the product from the thick seams . . . or about 16% of the original coal." He suggests that the medium and thin coal is unsuited for use and undesirable under present conditions. According to map No. 2, this would place the coals of the Grape Creek and of Peoria, Fulton, and McLean counties in the undesirable class. It occurs to me this is a mistake for the thin and medium coals which are shipped out of the State are nevertheless mined at a profit and are a source of wealth to the State. If Mr. Bement would exclude them merely because they are shipped away, he should also exclude the thick seams tributary to Saint Louis which annually send to that market, 6,000,000 or more tons; and he should include likewise in the coal resources of the State some consideration for coals of neighboring States, like Indiana, which are shipped *into* the Chicago market to the extent of 3,000,000 tons or more annually. I think we really should include the medium and thin seams in our estimate of coal resources, because to a great extent these will remain in reserve for the time when the thicker seams have been exhausted. It is possible that with a slight change in our mining laws requiring all of the coal to be taken out of the ground that the center of production might show a tendency to return to those fields which are closer to the big markets, because doubtless the waste of thick coal in the southern field is one of the factors which permits cheap production.

Doubtless some of the other gentlemen present will discuss Mr. Bement's coal analyses. They certainly indicate clearly the important features of the different coal fields. It has occurred to me that it would be interesting to compare with these analyses one from Shelby county from a seam known as No. 14, in the report of the State Inspector. This shows in the dry coal,—ash 7.85 and B. t. u. 13,234. It has a high reputation locally, displacing other coals in the home market. This and one or two other cases might be mentioned to show that there are exceptions to Mr. Bement's rule that in general lower coals are better than the higher seams. It has been suggested that the analyses of coal in the southern counties might have some bearing on the correlation studies of coals Nos. 6 and 7. I do

not know how the analyses may be interpreted but a number of analyses of face samples of this seam are presented in the preceding table X. (See page 341).

Group (A) includes various mines from Coulterville, in Randolph county, to Duquoin, along the Illinois Central R. R.

Group (B) includes mines on the east side of Duquoin and reaching into Franklin county.

Group (C) represents the same seam in the adjoining part of Jackson county.

Group (D) in the adjoining corner of Williamson county.

Mr. E. E. R. Tratman, M.W.S.E.: This paper is an interesting and valuable presentation of the coal resources and coal production of the State and there are two particular suggestions which occur to me. In the first place, reference is made to the fact that only a small percentage of the total amount of coal is commercially available under present conditions, and it is stated that while the coal remaining is about 99½% of the original total supply, the really desirable portion is only 16% of the original total. It seems probable, however, that with the conditions of increasing demand and decreasing supply, there will be a development in methods for obtaining and utilizing economically the inferior grades of coal and the less accessible coal beds. In the old days of the Pennsylvania anthracite mining, the smaller sizes went to the dump as waste because there was no known method of consuming it commercially, but with the development of special furnace construction, the old waste banks or culm banks become available as a supply of commercial fuel. The same has held good in many other mining cases. Thus in the gold fields, the first workers took only what was of greatest value and most easily obtainable. Their refuse and waste was afterwards worked over by other more careful miners, and eventually the Chinaman washed the tailings of the tailings and made a good picking from his work. So when the best and most available coals of Illinois begin to disappear, there will undoubtedly develop methods for obtaining and consuming the inferior grades and the less accessible beds.

The references made by Mr. Bement to the methods of mining employed, suggests to me that it would be to the interest of the Society to follow this paper with one on Coal Mining in Illinois, its Methods and Machinery. These two papers would then form a most valuable treatise on the coal resources of Illinois, and their working, while we already have in the bulletins of the State University very valuable information as to the chemical analyses and the availability for various purposes of the different grades of Illinois coal.

Mr. George S. Rice, M.W.S.E. (U. S. Geological Survey.): I am inclined to think that Mr. Bement has been ultra-conservative in his estimates, in showing so small an area of coal adaptable for competition, as only one-half of one per cent. The term, competitive, is of course, subject to wide variations according to financial conditions, but allowing for the unusual over production of the last few

years, which naturally affected the price, I believe it will be found that there is a very much larger percentage of the area available competitively even under present general conditions than indicated.

I am glad to note that Mr. Bement calls attention to the reckless use of explosives in mines of Franklin county. I think in this he might include some of the adjacent counties. Even after using undercutting machinery, the drill holes are frequently so placed that they are nearly equivalent to shooting "off the solid."

Regarding Mr. Bement's discussion of the relation of the No. 6 seam with the so-called No. 7 seam, from such information as I have, I agree with Dr. Bain and Mr. De Wolff of the Illinois Geological Survey that it is one and the same seam, characterized as Mr. Bement mentions, by a shale of clay parting varying from a knife edge to four inches in thickness, and located from one to three feet above the floor, proportionate to the thickness of the seam. This "blue band" can be found from the Cherry Mine in the extreme northern part of the coal field and where the seam is four to six feet thick to the extreme southern part of the Illinois coal field where the coal is from seven to nine feet thick. It also shows south of the Ohio River in the so-called No. 11 coal of western Kentucky. The relation of the No. 5 seam (Illinois) to the No. 6 or "blue band" seam is an interesting one. Considering the enormous area covered, the interval is remarkably uniform, varying from 40 to 70 feet.

A point of interest in No. 5 seam is the almost universal presence of "horse-backs" and "clay-slips," which are far more prevalent than in the No. 6 seam. The inference is, that there must have been a period of cessation in roof making, and during this period, the No. 5 coal had a very shallow cover; hence was subjected to surface influences.

Mr. Bement speaks of the well known anticlinal fold which extends from Wisconsin, southeasterly through La Salle to the oil fields in southeastern Illinois. It is a fact not generally known that there is a small parallel fold a little to the west of Depue on the Illinois River and which runs parallel with the main fold. I traced the same for a distance of ten or fifteen miles. This does not show on the surface as the coal measures are deeply covered by an irregular thickness of glacial drift.

In this section of the northern field, it is interesting to note that the pre-glacial surface topography in the vicinity of the Illinois River was even more rugged than that of the present day topography.

Mr. Isham Randolph, M.W.S.E.: I have read with interest and profit the paper of our fellow member, Mr. A. Bement, on the "Illinois Coal Fields," and I regret that I cannot be among those who will hear him deliver it, that I might still further profit by hearing his answers to the many questions that I feel sure, will be asked of him.

This paper has especial value to me because it deals with questions that are most pertinent to the work of the men upon whom has

been imposed the duty of studying the natural resources of our State and making such recommendations for the conservation of those resources as shall seem to them wise after having made use of the best information made available by the intelligent research of men like Mr. Bement.

Just now I am wrestling with the waterway and water power resources of the State, trying to secure their conservation for our whole people and my post of duty is at Springfield.

Mr. Chas. A. Lind, (Fuel Agent Commonwealth Edison Co.): I regret my inability to present any discussion, but I can say something relative to the value of Mr. Bement's work, and wish to make acknowledgment to him for the assistance his experiments and researches have been to me in my position as a coal purchaser.

To him and to Mr. W. L. Abbott, more than anyone else, I think is due our knowledge of the Illinois coal field and problems in general connected with the use of fuel. It is the work of these two men that gave the impetus to investigations concerning the use of fuels which have led to such work being taken up by a larger number of chemists, engineers and others.

Mr. S. W. Parr, (Professor of Applied Chemistry, University of Illinois): I have read with much pleasure the advance copy of Mr. Bement's paper on the Illinois Coal Field. This is a valuable contribution to our knowledge of the Illinois coal deposits, and has a very vital bearing upon the question of the conservation of this most important of our natural resources.

Mr. R. Y. Williams, (Mining Engineer, U. S. Geological Survey): In the work assigned to me by the United States Geological Survey in the operation of their Branch Station at Urbana, Illinois, an investigation is being made into those phases of the coal mining industry which have been leading toward greater hazards to life and property, and which have also resulted, more in the past than in the present, in the employment of wasteful methods of mining. Mr. Bement's paper is therefore very valuable to me as a summary, both of the past history and the present status of the several Illinois coal fields.

The figures showing the increase in the use of powder is an important one, believing as we do that reckless use of powder is in a very large measure responsible for the great number of fatalities in the present method of mining. The logarithmic curve applied to powder consumption per ton of coal produced would probably show an increase at an increasing rate, while as Mr. Ray shows, coal is increasing at a constant rate.

An interesting fact is brought out by the statement that the Pocahontas coal when arriving in Chicago carries over 8% ash. The West Virginia Geological Survey claims from face samples $5\frac{1}{4}\%$ ash as the average of ten samples of the Pocahontas No. 4 seam, and $5\frac{1}{2}\%$ ash as the average of thirty-eight samples of the Pocahontas No. 3 seam. Here is a difference of at least 33% between the two methods of sampling in arriving at the ash contents.

The figures of 57% is interesting. Last month I examined several mines in the Grape Creek district and was led to decide upon 57% as the number representing the percentage of recovery.

These figures on mining waste are difficult of ascertainment. As a rule the operator's statement of recovery is liable to be high; and to obtain a reliable estimate the figures must be obtained first hand. An operator mining on the room and pillar system with rooms 24 ft. wide and room pillars 8 ft. wide will say that he is obtaining 75% of the seam. However, careful figuring shows that the theoretically largest amount possible is only 57%. As this special practice is particularly unsuited to the field where used, the final yield is only 40%, due to squeezes, etc., which the system invites; still the operator believes he is honest when he claims a recovery of 75%.

The preparation and discussion of papers such as Mr. Bement's; the holding of such gatherings as the Illinois Fuel Conference at Urbana, Ill., March 11th to 13th; the meeting together of mine inspectors and operators such as took place at Springfield, Ill., April 1st; and the agitation that is being made to have a Mining Engineering course included at the State University, show plainly that Illinois has awakened to a general desire for safer and saner conditions in its fuel industry.

Mr. E. H. Taylor: We are certainly indebted to Mr. Bement for the care he has taken in gathering together the data presented in this paper. I have read the paper over carefully and find that all of the statements contained therein with which I am familiar, check with the information that I have gathered in my personal work during the past four years, with possibly a few exceptions. It might be well to call attention to these exceptions. I think that Mr. Bement has placed too high a value upon Saline county coal, although the coal from this field is certainly entitled to a great deal of prominence owing to its very good quality. Nothing that I have seen indicates that it is five per cent better than Hocking Valley. The calorific value of the seam sample of Saline county coal as shown in table 8, is 13,882. This, I believe, is approximately 175 or 200 B. t. u. higher than it should be. At present my office has occasion to sample and analyze from ten to fifteen cars of Saline county coal every day. This coal comes from a number of different mines and of late I have been segregating the same so I could get definite data upon each of the various mines. In no instance, however, have I found coal of as high calorific value as Mr. Bement reports. The ash in the seam samples, 7.75%, strikes me as being rather low. At least, not a fair average for the entire county, although possibly correct for some particular mine. There is considerable difference in the ash content in the various mines of Saline county; in the slack coal which we receive, the same varies from 13% to 18% in ash. This difference is not entirely due to roof and bottom, but to the seam itself. The moisture determination in this seam sample, is about correct as an average for the county, although some of the mines have a seam

moisture of as low as 4%. The data given in table 8, No. 2 seam, from the Wilmington field, with which I am quite familiar, is about 300 B. t. u. lower in calorific value than the figures which I have obtained. We are receiving coal from this field every day and our analyses cover a period of over two years. The B. t. u. determination calculated at 5.87% of ash would be 13,616 instead of 13,367. This calculation is taken from the tables which we have compiled on the coal in the various counties. These tables were made by taking a 10 lb. sample of screenings, just as the same comes from the mine. These samples are separated into two parts, one containing the clean nut coal which would represent the lump as coming from the mine and for convenience called (A) coal, and the remainder containing all of the fine coal and dirt which would represent the dirtiest screenings which the mine would ordinarily produce, called for convenience (F) coal. Upon these two samples, calorific, ash and sulphur, determinations are made. Then, by mixing the A and F together in varying proportions samples are produced with varying degrees of ash, in every case making at least four of these mixtures. Ash and calorific determinations are then made upon these four samples so mixed, making with the two original samples, six in number, then we plotted the ash against the B. t. u. We find in every case that the curve is a straight line and that the B. t. u. decreases a certain fixed amount for each per cent of increase in ash. This definite number of B. t. u., however, varies with the various coals, fluctuating from 150 B. t. u. in some, to 175 in others. These tables have been made upon each of the principal mines in the various counties of the State. Against these tables we check all of the determinations which are made each day in our laboratory. Whenever we find the "Mahler" determinations do not check within 50 B. t. u. of the table on the coal it is supposed to be, we run an additional Mahler test. If the second Mahler test checks with the first, we then suspect that the coal we are analyzing is not the coal it is reported to be. We then check the two determinations made on the Mahler with other tables and endeavor to locate the kind of coal the sample is composed of. This we have found to be the best way of identifying various coals. I have compared all of the calorific determinations in table 8 with our tables upon these various counties. The results, I believe, will be interesting:

	Mr. Bement's Table No. 8 B. t. u. dry	Commercial Testing & Eng. Co. Laboratory Tables B. t. u. dry with same Ash
Seam No. 1	13,473	13,468
Seam No. 2 Wilmington	13,367	13,616
Seam No. 2 Northern	12,983	12,963
Seam No. 5 Springfield	12,583	12,504
Seam No. 5 Peoria and Fulton	12,166	12,181
Seam No. 5 Saline	13,882	13,701
Seam No. 6 All fields	12,584	12,546
Seam No. 7 Williamson and Franklin	12,737	12,788

TABLE I.

*U. S. G. S. STEAMING TESTS
WITH ILLINOIS COAL*

ARRANGED WITH RELATION TO COUNTIES.

COUNTY	No. OF TESTS AVERAGED	MOISTURE	ASH	B.t.u.	EFFICIENCY OVER-ALL PER CENT
		PER CENT OF COAL AS FIRED		PER LB. OF DRY COAL	
LA SALLE	4	13.61	7.49	13 232	63.26
LOGAN	2	14.62	12.60	12 145	60.63
SANGAMON	5	14.38	12.81	12 082	61.75
MONTGOMERY AND MACOUPIN	15	13.73	11.68	12 265	56.59
MADISON	22	13.01	13.09	12 087	62.02
CLINTON AND MARION	8	11.92	12.75	12 229	60.12
ST CLAIR	5	11.03	11.73	12 467	62.41
FRANKLIN	23	10.53	10.22	12 931	63.94
WILLIAMSON AND SALINE	27	7.90	11.93	12 642	61.67

Table I.—Discussed by L. P. Breckenridge, p. 356.

There is one statement I wish to make regarding the tables we have made on coal from various mines in the state. I find that the same check very closely with our regular Laboratory determinations. We have made tables upon some mines each year and find that they check remarkably well. For instance, in the No. 5 seam, in the Springfield field, we have made three tables upon one mine and find that the variations in calorific value covering a period of three years, at 15% ash, amounts to only 20 B. t. u., showing that the coal in that area remains practically the same in calorific value. We have tried the same experiment in several of the different fields and it checks out the same way each time. Recently, Mr. Carl Scholz, President of the Coal Valley Mining Co., sent us samples of coal which his company is delivering to the Rock Island Arsenal. These samples were to be analyzed and checked against samples to be analyzed by the United States Government, the coal being sold upon heat value basis. The determinations varied considerably in ash and B. t. u. Not having definite data on the coal in Mercer county, I plotted the same and found that the calorific determinations were very irregular—that it would be impossible to draw a straight line through them. I asked Mr. Scholz for further information on the subject, and he turned over to me some twenty-five analyses made by the United States Government. Upon plotting these analyses, I found that only five of them ran on a straight line and that the other twenty were badly scattered. These five, however, were all in one month—the

U. S. G S STEAMING TESTS ILLINOIS COAL
FIG. 1 OVER-ALL EFFICIENCY

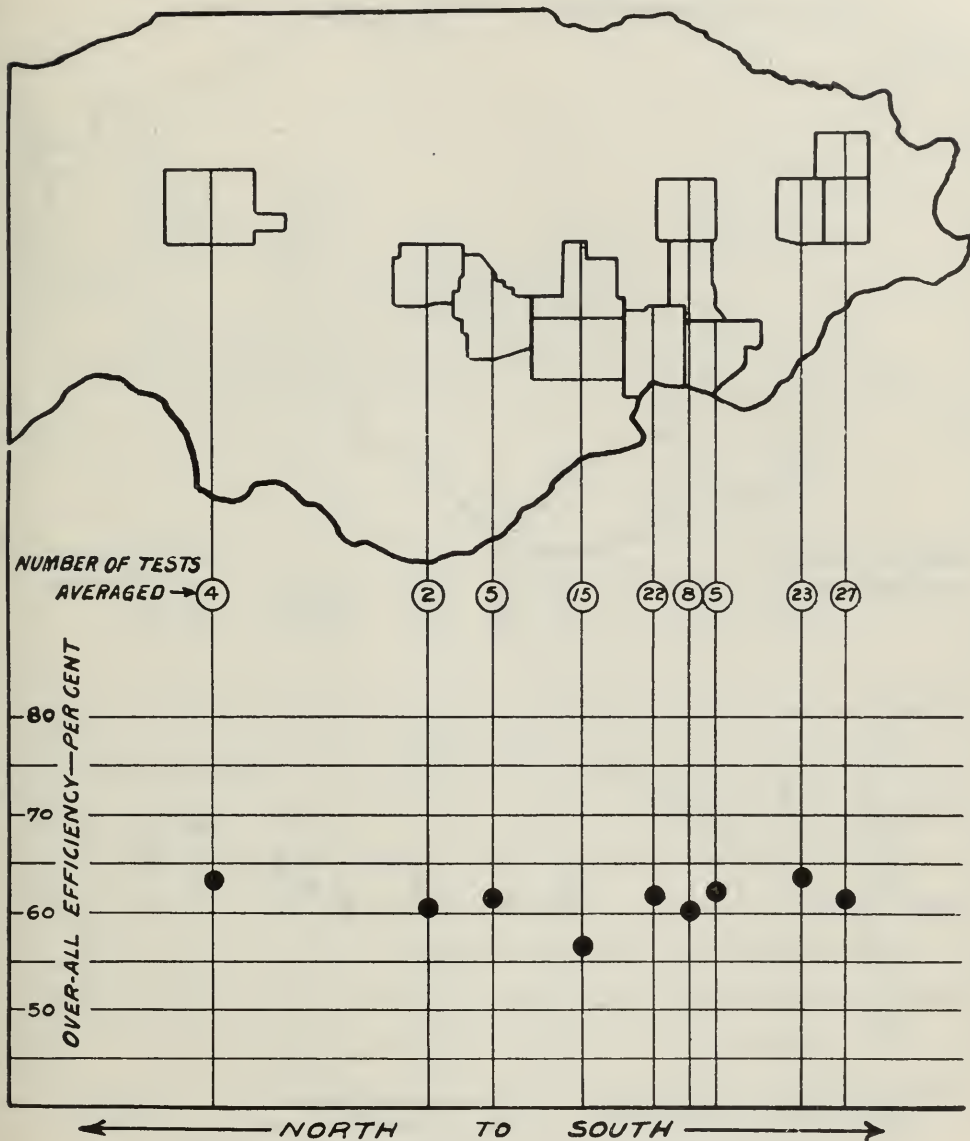


Fig. 1.—Discussion by L. P. Breckenridge, p. 356.

month of December, the per cent of ash in these samples varied from 10% to 17%. I took the subject up with Mr. Scholz and found that the coal represented by these five analyses was from the old Cable mine which was about to be abandoned, and was pillar coal and had been exposed a long time. I also found that the remaining twenty analyses were on coal loaded from the Sherrard mine and that probably the reason for the calorific value varying so greatly was due to the fact that they were mining fresh coal in one entry and pulling pillars which had been exposed for a number of years in another entry, the pillar coal being much lower in calorific value.

Referring again to table 8, I would suggest that an additional column be added, headed "Sulphur," believing that the sulphur con-

U. S. G. S STEAMING TESTS ILLINOIS COAL
FIG 2 CALORIFIC VALUE

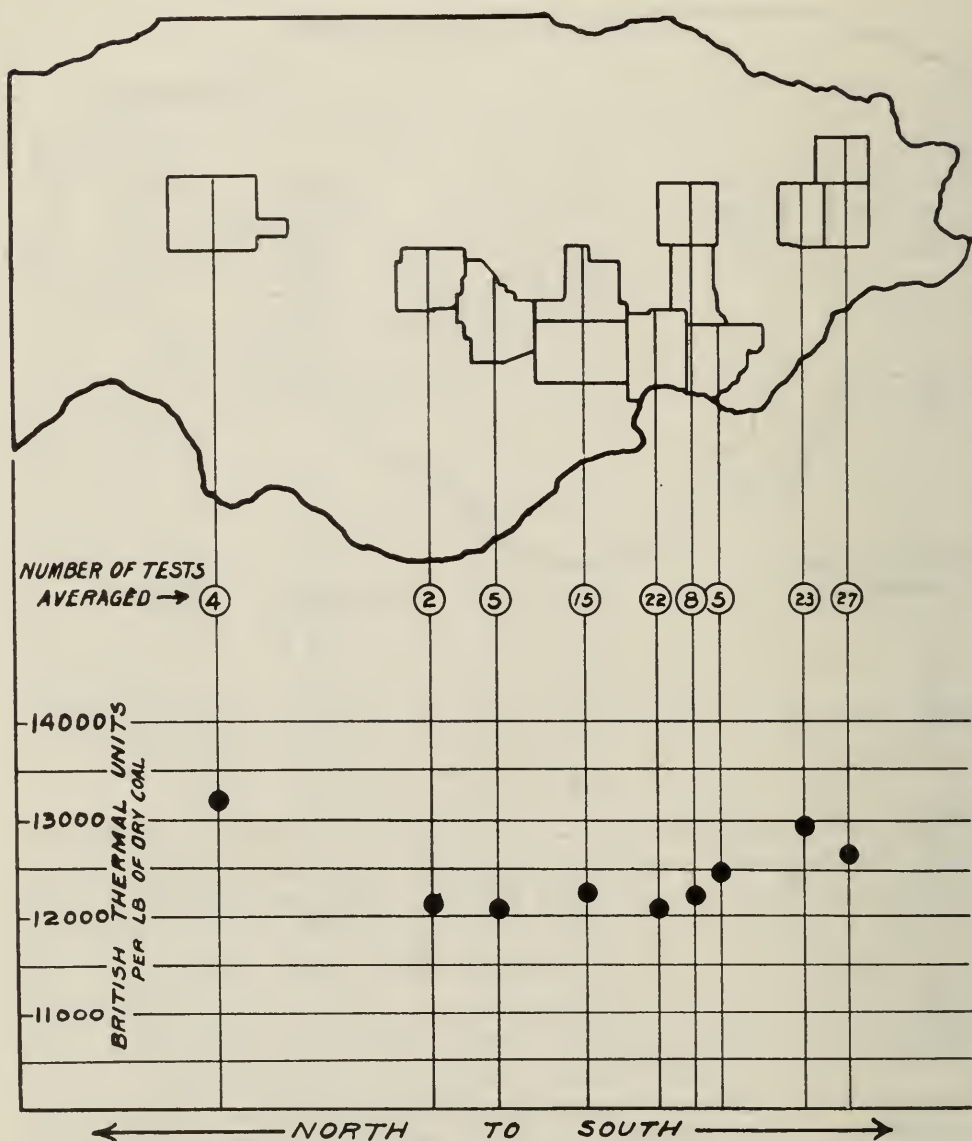


Fig. 2.—Discussion by L. P. Breckenridge, p. 356.

tent of the various seams in Illinois is fairly constant. The first time I made this statement I was taken to task for it, on the grounds that it was impossible to take an average seam sample. This I will admit is true as the sulphur in nearly all of the mines in Illinois varies with each foot of the face exposed. It would be impossible to cut a sample from the seam in any mine which would be representative of the entire seam. The characteristic sulphurs on the seam which I propose, however, were not obtained in this manner, but have been obtained in our regular work from mine run shipments, which in my opinion represents the sulphur in the seam. We all know that it is impossible for sulphur other than that which is in the seam to get into the coal as mined, the mining conditions being

U. S. G. S. STEAMING TESTS ILLINOIS COAL
FIG. 3 MOISTURE

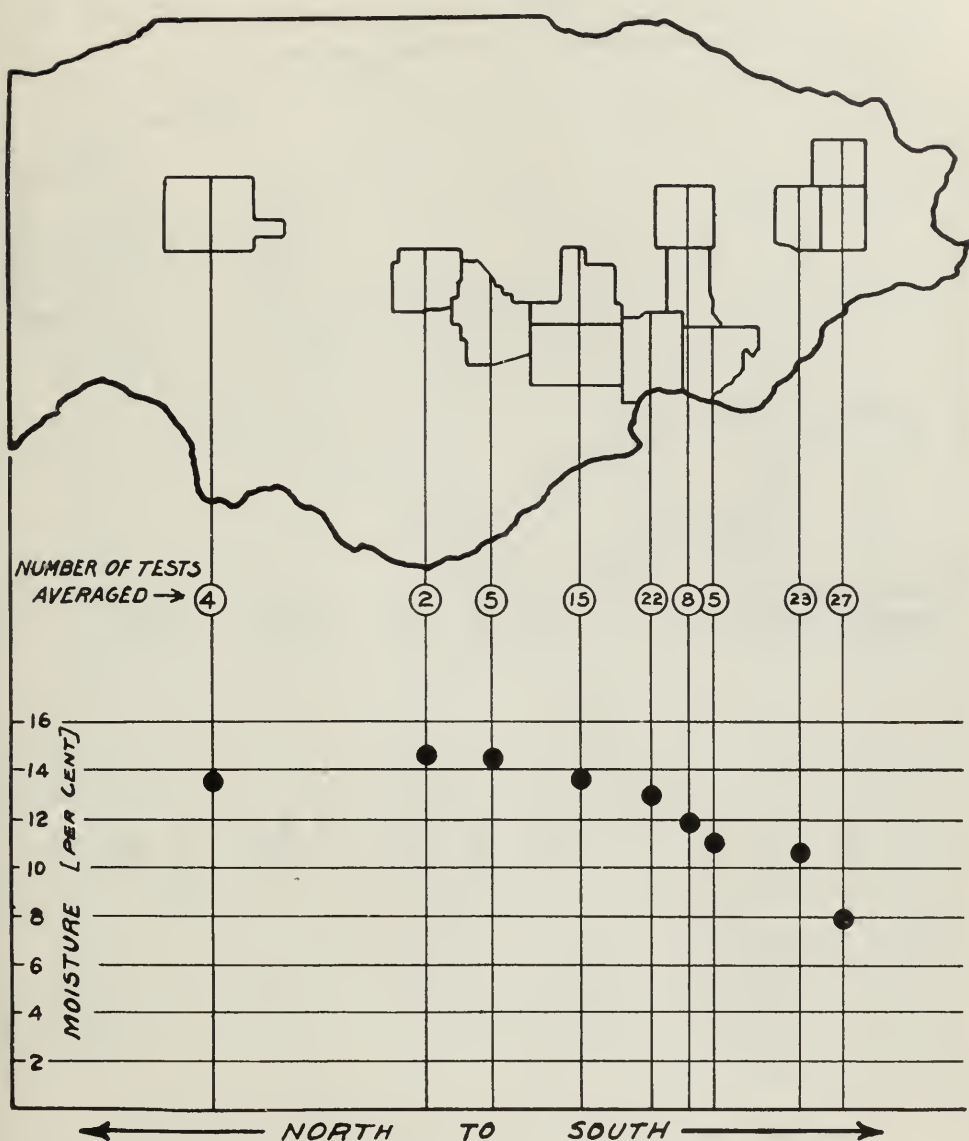


Fig. 3.—Discussion by L. P. Breckenridge, p. 356.

different from those regarding ash, which, of course, may come from the top or bottom, as well as the face of the seam.

The sulphur contents of the seam are as follows:

	Sulphur %
Seam No. 1	6.14
Seam No. 2 Wilmington	2.35
Seam No. 2 Northern	2.56
Seam No. 5 Springfield	4.09
Seam No. 5 Peoria and Fulton.....	4.46
Seam No. 5 Saline	2.54
Seam No. 6 All fields	5.68
Seam No. 7 Williamson and Franklin.....	2.65

U. S. G. S. STEAMING TESTS ILLINOIS COAL
FIG. 4 ASH

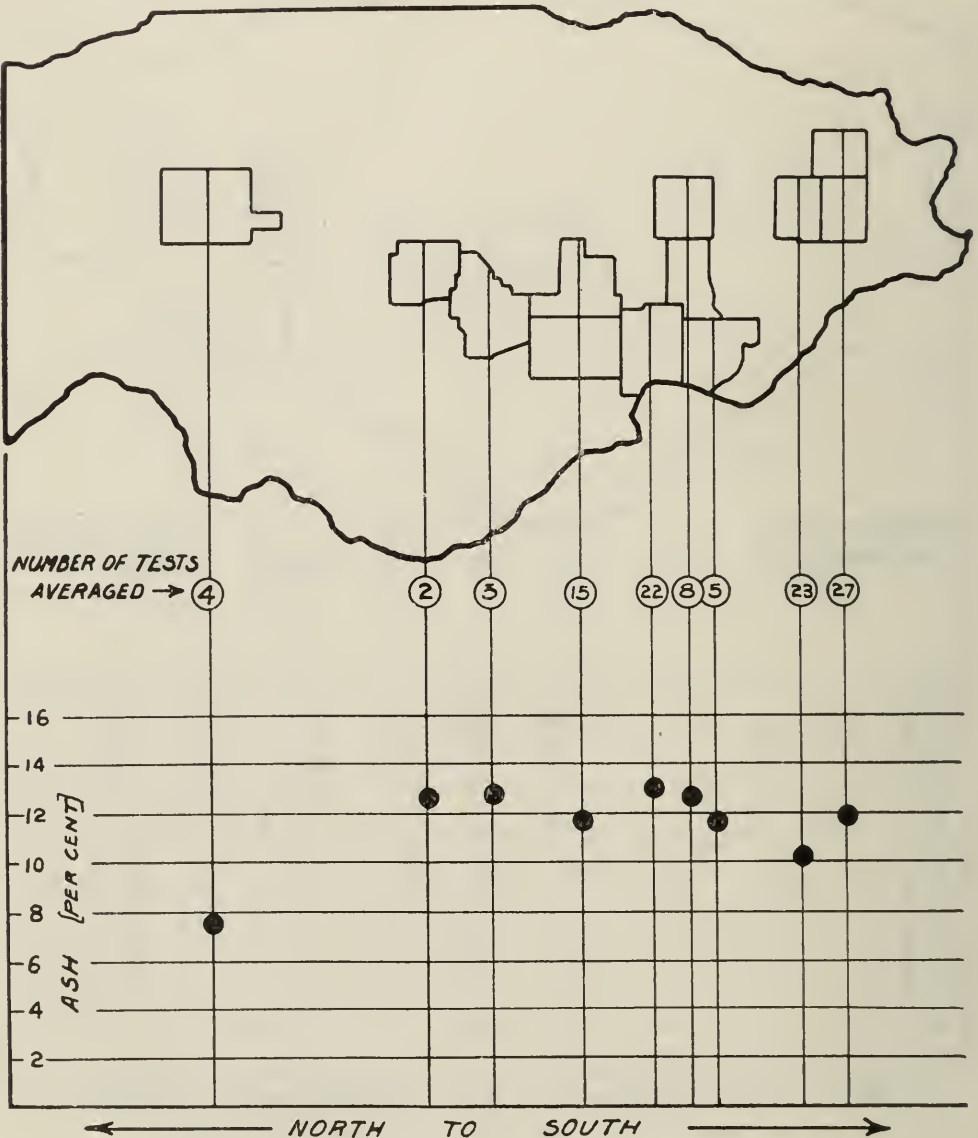


Fig. 4.—Discussion by L. P. Breckenridge, p. 356.

Referring again to the table work which we have done on Illinois coal, I wish to call attention to one very interesting fact which we have noted regarding the sulphur determinations.

In some tables, the sulphur in the A and F coal are the same, while in other tables the A and F coal differ greatly. For instance, in Perry county, the Majestic mine, we find the sulphur in the A coal is 0.84 and the F coal 0.93, while the White Walnut mine at Pinckneyville, the same county, although a different seam varies as follows:

TABLE II

U. S. G. S. STEAMING TESTS WITH ILLINOIS COAL

ARRANGED WITH RELATION TO DEPTH OF MINE

DEPTH OF MINE. FEET	NUMBER OF TESTS AVERAGED	MOISTURE	ASH	B.T.U. per lb. of DRY COAL	EFFICIENCY [OVER-ALL]
		PER CENT OF COAL AS FIRED			PER CENT
635	2	10.91	11.91	12427	62.96
630	4	9.97	9.47	12940	65.92
544	4	13.88	12.03	12121	57.98
500	7	11.17	11.40	12573	54.62
417	14	10.73	10.23	12977	66.13
392	4	13.61	7.49	13232	63.26
345	2	11.91	12.73	12271	58.21
325	9	13.83	11.25	12383	57.29
320	4	12.44	13.18	12110	59.60
300	2	12.67	12.54	12319	64.63
286	4	11.93	10.48	12639	65.02
280	2	13.03	11.40	12443	56.81
276	2	14.62	12.60	12145	60.63
275	3	15.78	12.01	12218	63.93
270	2	15.91	13.86	11772	65.42
260	3	12.13	12.60	12095	63.77
240	3	13.36	12.11	12288	59.29
200	2	10.05	12.63	12212	60.10
185	7	8.90	13.87	12215	63.88
170	6	12.07	18.38	11164	60.30
167	4	6.24	10.78	12846	65.03
165	1	6.56	7.72	13621	62.53
150	13	7.84	11.73	12699	58.98
145	4	14.05	9.79	12636	61.48
140	1	9.16	10.23	12874	68.11
126	1	9.75	8.31	13271	62.58
100	1	8.51	11.55	12857	60.39

Table II.—Discussion by L. P. Breckenridge, p. 357.

Sulphur in A coal 2.53.

Sulphur in F coal 4.49.

From these figures, it is apparent that the sulphur in the Majestic mine is inherent in the coal, while the sulphur in the White Walnut mine is, to quite an extent, extraneous matter, and can be separated from the coal.

Referring to Mr. Bement's Map No. 3, I believe it will be of interest to give the calorific value for each of the 14 different fields he calls attention to, as I have noted them.

This calorific value is based in each case on the same per cent of dry ash in the coal, which is 10%.

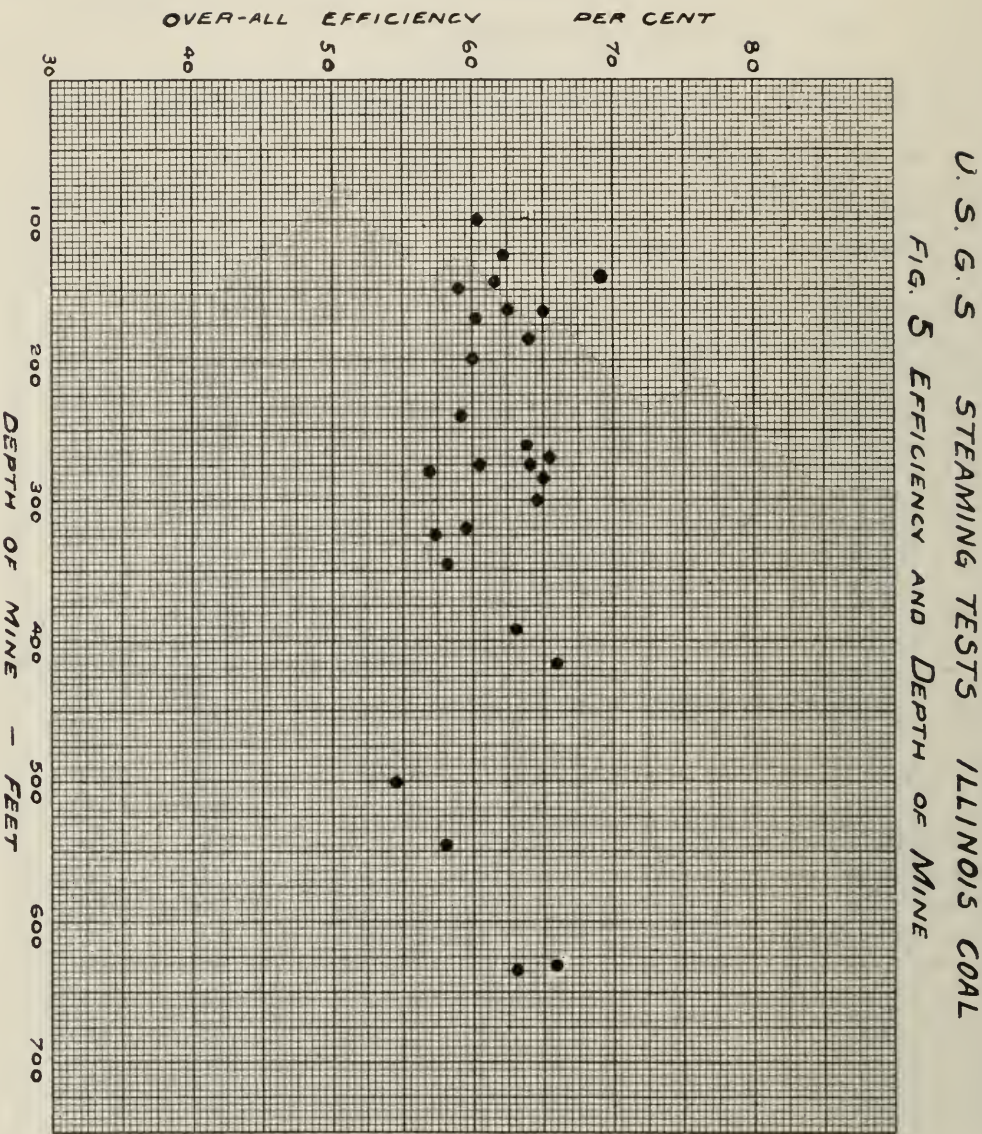


Fig. 5.—Discussion by L. P. Breckenridge, p. 357.

		Dry B. t. u.
No. 1	Rock Island	12,987
No. 2	Northern	12,910
No. 3	Wilmington	12,963
No. 4	Peoria and Fulton	12,900
No. 5	Grape Creek	13,057
No. 6	Springfield	12,850
No. 7	Viriden	12,669
No. 8	Pana	12,765
No. 9	Central Illinois	12,832
No. 10	Centralia	12,874
No. 11	Duquoin	12,821
No. 12	Williamson and Franklin	13,112
No. 13	Big Muddy	13,205
No. 14	Saline	13,296

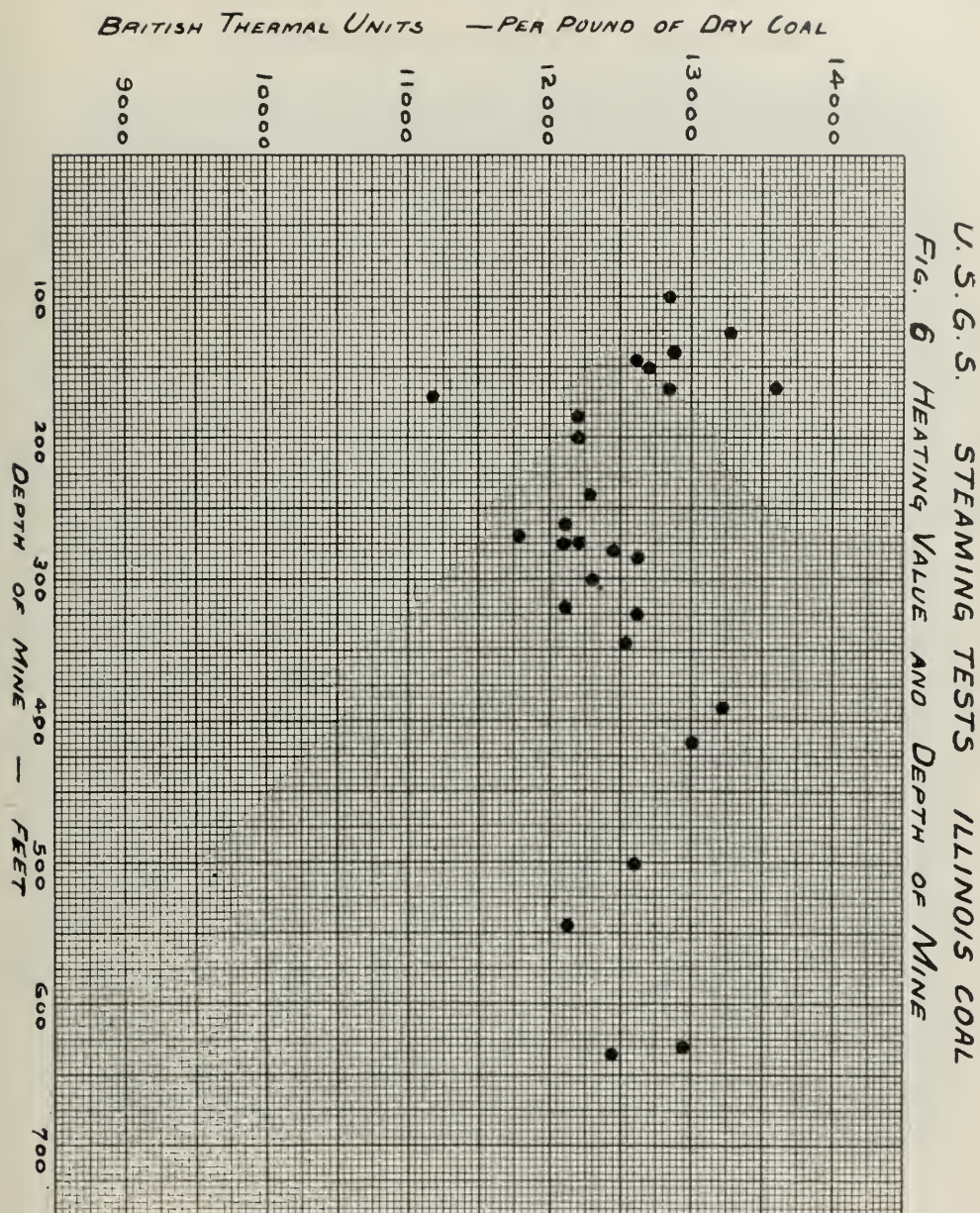


Fig. 6.—Discussion by L. P. Breckenridge.

Prof. L. P. Breckenridge, M.W.S.E., (University of Illinois.): This paper upon the Illinois coal field, presents a very great deal of up-to-date information concerning this most important phase of the producing and manufacturing interests of the state. The Society is to be congratulated upon its ability to include in its transactions just at this time, so comprehensive a statement and so much useful information concerning the coal industry of the State of Illinois.

A statement made upon page 319 was found most interesting. This reads as follows:

"As a general proposition in Illinois, the quality of coal seams increase with depth, the lower ones being superior to the upper. There is also an increase in quality from the North to the South.

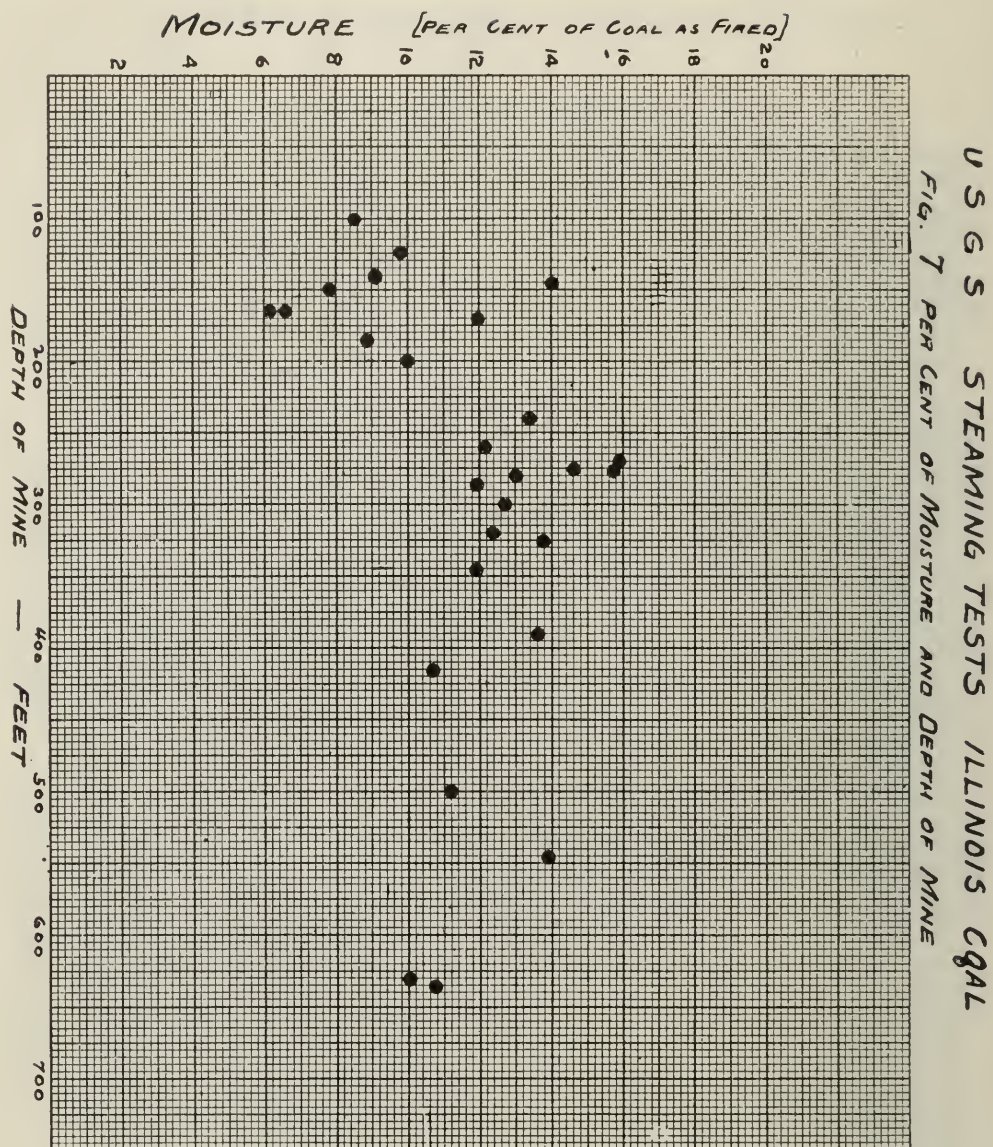


Fig. 7.—Discussion by L. P. Breckenridge.

the beds in the southern part of the state being superior, as a general proposition, to those in the North; this is particularly true of the heating power content."

With relation to this statement I have extracted from the U. S. G. S. bulletins certain information relative to steaming tests made upon Illinois coal, which is tabulated in Tables I and II.

*Table I presents information relative to the moisture and ash contents of the coal, heat content and overall efficiency as obtained by steaming tests, all shown as arranged by counties. In all, 111 tests have been so arranged. The same information is shown graphically in Fig. 1, 2, 3 and 4, the various values tabulated being plotted as ordinates to a base line which is a North and South line through the State. For the tests plotted it is only in the case of moisture, Fig. 3, that there is any tendency of improvement along such a North and

*See pages 348, 49, 50, 51 and 52.

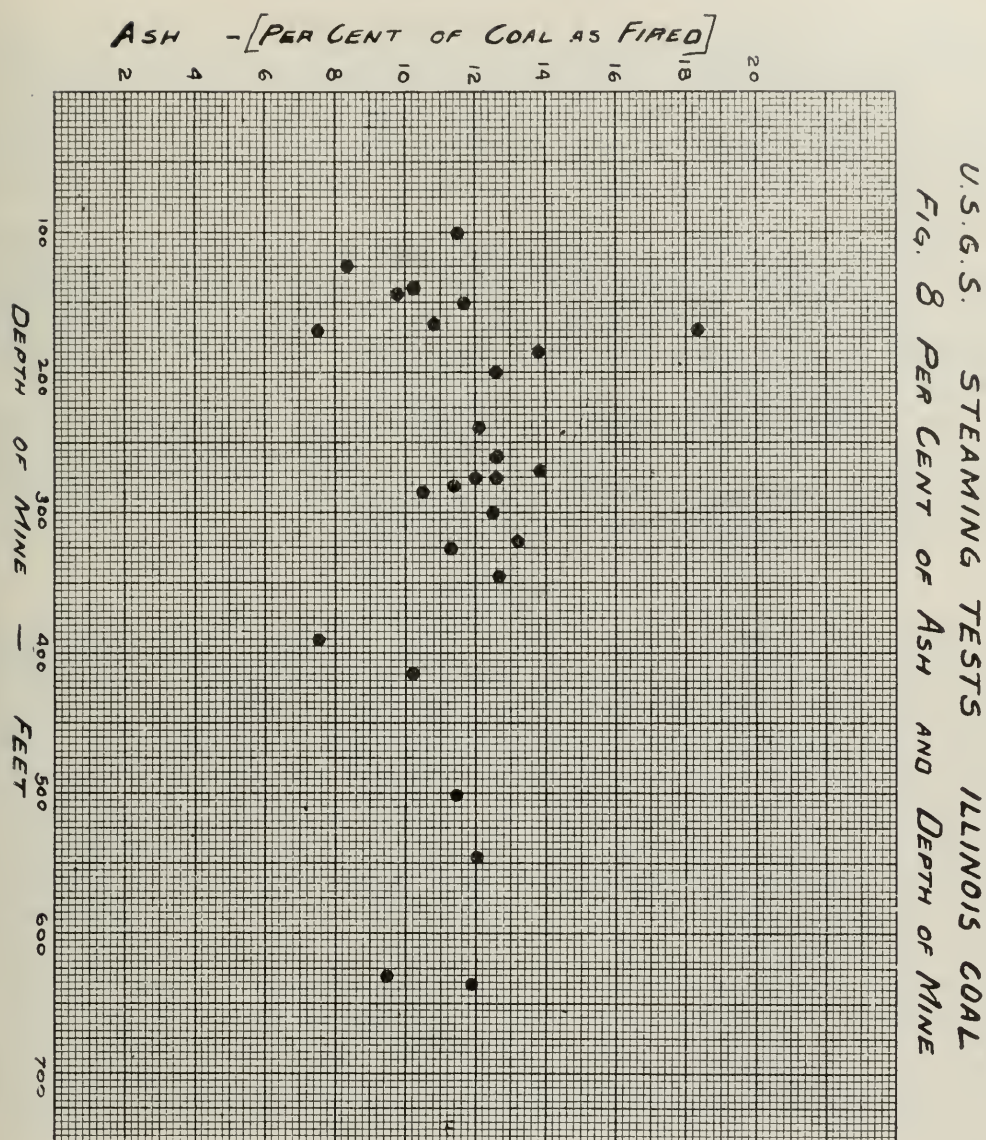


Fig. 8.—Discussion by L. P. Breckenridge.

South line proceeding from North to South. Table I shows the number of tests averaged, in obtaining each of the eight points plotted.

Table II presents the same information tabulated with relation to depth of mine and Figs. 5, 6, 7 and 8 show this data graphically* Here again no decided tendency is shown in improvement as the depth of mine increases. The most complete data given and those most easily obtained from the U. S. G. S. bulletins have been used in making these comparisons, that is moisture and ash content of the coal as fired have been used instead of similar figures from mine samples which would be better if accurate and available.

The III tests represent four seams, Nos. 2, 5, 6 and 7. The same data as used in the other diagrams when classified and plotted with relation to the number of the seam did not show results differing

*See pages 353, 54, 55, 56 and 57.

greatly from those shown and such classification and diagrams have not been included here. Owing to the uncertainty as to the number of the seam worked in some localities, it is difficult to satisfactorily classify with respect to seam numbers. In the case of a few tests the depth of mine as used in compiling Table II was not known exactly.

There are of course a great many variables entering into a number of tests such as those from which the data have been selected. The coal graded all the way from slack to run-of-mine, including washed and raw coals of various sizes. In a few cases the coal was burned as briquets.

No attempt is here made to indicate these differences, the idea being merely to see if a large number of analyses and tests made, throughout, under practically similar conditions would show results in accordance with the statement first quoted.

CLOSURE.

Mr. A. Bement, M.W.S.E. Mr. Dering and Mr. Abbott have both called attention to the necessity for Federal regulations controlling the amount of coal removed in mining. It is a matter of the greatest importance and one which justifies immediate attention. The Government, by ex-President Roosevelt, has inaugurated a vigorous campaign for the conservation of natural resources, among which coal was given due prominence. The United States Geological Survey has done a very large amount of work having a direct bearing on the conservation of coal resources, but everything thus far which has been done would be a matter of insignificance compared to the benefit which would be derived by Federal regulations concerning the percentage of recovery in mining. The matter should be put in the hands of a competent and independent commission, and upon its recommendations necessary legislation should be enacted and the result should in no wise be dependent upon the opinion of any operator.

Mr. Naylor has made a useful suggestion, and I am glad to amplify the matter in accordance therewith, therefore present the following tabulation:

COAL FIELD	COUNTIES	PRINCIPAL CITIES
No. 1	Mercer	Sherrard
No. 2	La Salle Putnam Marshall Woodford Livingston	La Salle Streator
No. 3	Grundy Kankakee Will	Coal City Braceville

COAL FIELD	COUNTIES	PRINCIPAL CITIES
No. 4	Fulton Peoria Knox	Peoria Farmington Yates City Canton
No. 5	Vermilion	Grape Creek Westville
No. 6	Logan Menard Sangamon	Lincoln Petersburg Springfield
No. 7	Sangamon Christian Montgomery Macoupin	Virден Taylorville Girard Carlinville
No. 8	Christian Shelby Montgomery Fayette Bond	Pana Witt Hillsboro Sorento
No. 9	Macoupin Madison Clinton St. Clair Washington Randolph	Gillespie Mt. Olive Edwardsville Collinsville Belleville Breece Nashville Sparta
No. 10.	Marion	Odin Sandoval Centralia
No. 11.	Perry Jackson	Duquoin Pinckneyville
No. 12.	Franklin Perry Jackson Williamson	Benton Carterville Marion
No. 13.	Jackson	Murphysboro
No. 14	Saline	Harrisburg Eldorado

Through the courtesy of the Lovington Coal Mining Co. at Lovington, Ill., in Moultrie county, I am able to present below the record of a diamond drill prospect made by the Sullivan Machinery Co., and as it is such a complete record of a very deep hole it possesses considerable value. Mr. Arthur E. Hanson, Secretary of the Company, states that below this 8 ft. 10 in. seam, at a depth of 927 ft., they have found another between 4 and 5 ft., and that there is now a difference of opinion as to whether the 8 ft. 10 in. seam is No. 1 or No. 2, which illustrates the general opinion that the coal bodies in the lower measures are definite and individual seams. Among the state mine inspectors, one considers that the 8 ft. 10 in. seam is Nos. 1 and 2 combined; another, that it is seam No. 6.

Record from diamond drill at Lovington, Ill.:

Depth from Surface. From To Feet and In. Feet and In.		Thickness of Strata. Feet and In.		Material.	
0	2	2		Black Soil	
2	14	12		Yellow Clay	
14	72	58		Blue Clay	
72	75	3		Gravel	
75	83	8		Hard Clay and Gravel	
83	90	7		Gravel	
90	116	26		Hard Clay and Gravel	
116	127	11		Sand	
127	132	5		Red Clay	
132	145	13		Red Clay and Gravel	
145	149	4		Sand Rock	
149	153	4		Sand Shale	
153	182	29		Blue Sand Shale	
182	184	2		Sand Shale	
184	202	7	18	7	Sand Stone
202	7 202	3		10	Coal
203	5 204			7	Sand Stone
204	211	7			Clay Shale
211	215	4			Sand Stone
215	229	6	14	6	Blue Sand Shale
229	6 243	13	6	6	Dark Shale with Sandstone Bands
243	255	5	12	5	Blue Shale
255	5 257	5	2		Coal
257	5 273	15	7	7	Sand Shale
273	297	8	24	8	Dark Blue Shale
297	8 299	1	4	4	Fossiliferous
299	302	6	3	6	Black Shale
302	6 303	6	1		Coal
303	6 308	4	6	6	Clay Shale
308	331	23			Dark Sand Stone
331	332	1			Fossiliferous Shale
332	350	9	18	9	Dark Blue Shale
350	9 351		3		Coal

Depth from Surface. From To		Thickness of Strata.			Material.
Feet and In.	Feet and In.	Feet and In.			
351		353		2	Fire Clay
353		358		5	Clay Shale
358		363		5	Lime Stone
363		369		6	Clay Shale
369		372		3	Conglomerate
372		397	8	25 8	Lime Stone
397	8	400		2 4	Dark Sand Shale
400		411	10	11 10	Sand Shale
411	10	412		1 3	Coal
412	1	416		3 11	Sand Shale
416		425		9	Blue Shale
425		433	3	8 3	Dark Blue Shale
433	3	433	4		1 Coal
433	4	439	9	6 5	Dark Blue Shale
439	9	440	2		5 Coal
440	2	443		2 10	Blue Sand Shale
443		448		5	Sand Shale
448		453		5	Sand Stone
453		476	10	23 10	Dark Blue Shale
476	10	477	6		8 Coal
477	6	482		4 6	Clay Shale
482		483		1	Lime Stone
483		485		2	Blue Shale
485		490		5	Red Shale
490		501	6	11 6	Blue Shale
501	6	502			6 Black Shale
502		503	11	1 11	Fossiliferous Shale
503	11	505	2	1 3	Coal
505	2	509		3 10	Clay Shale
509		519		10	Shaley Sand Stone
519		541		22	Dark Sand Stone
541		559		18	White Sand Stone
559		582		23	Sand Stone
582		584	6	2 6	Blue Shale
584	6	588		3 6	Nodular Lime Stone
588		593	7	5 7	Lime Stone
593	7	594	7		1 Black Shale
594	7	605		10 5	Dark Blue Shale
605		608		3	Clay Shale
608		611		3	Blue Shale
611		627		16	Sand Stone
627		628		1	Blue Shale
628		642	6	14 6	Dark Blue Shale
642	6	645	8	3 2	Black Shale
645	8	646	2		6 Coal
646	2	652		5 10	Clay Shale
652		656		4	Sand Stone

Depth from Surface. From To		Thickness of Strata.				Material.
Feet and In.	Feet and In.	Feet and In.				
656	657		1			Blue Shale
657	664		7			Sand Stone
664	675		11			Sand Stone, Shale Partings
675	684		9			Dark Sand Shale
684	714	6	30	6		Dark Blue Shale
714	6 715			6		Black Shale
715	716		1			Coal
716	718	6	2	6		Clay Shale
718	6 723		4	6		Blue Sand Shale
723	732		9			Sand Shale
732	740		8			Lime Stone
740	741	6	1	6		Blue Shale
741	6 754	4	12	10		Lime Stone
754	4 756		1	8		Dark Blue Shale
756	763		7			Gray Shale
763	782		19			Sand Stone
782	801		19			Dark Sand Stone
801	825		24			Dark Blue Shale
825	830		5			Black Shale
830	840		10			Dark Blue Shale
840	850		10			Blue Shale
850	866		16			Dark Blue Shale
866	873	6	7	6		Blue Shale
873	6 876	8	3	2		Coal
876	8 878	7	1	11		Shale Partings
878	7 879	11	1	4		Coal
879	11 883		3	1		Blue Lime Stone
883	888		5			Clay Shale
888	891		3			Black Slate
891	900	6	9	6		Blue Lime Stone
900	6 902	10	2	4		Black Slate
902	10 911	8	8	10		Coal
911	8 920		8	4		Sand Stone

My figures for coal production were taken from the Illinois State Reports, and Mr. Ray, in the presentation of his diagrams, called attention to the apparent incompleteness of the output for the year 1881, and in revising his discussion, has made some comments regarding the matter. I have prepared another and more extended estimate upon the following basis:

For the period from 1810 to 1833, I have assumed that the coal production began in the first year, and that the increase was at a constant rate until it arrived at 5357 tons in 1833;

For the period from 1833 to 1881, I have taken the figures prepared by Mr. Henry S. Fleming, of New York, Secretary of The Bituminous Coal Trade Association;

For the period from 1882 to 1908, inclusive, the figures as originally given in the paper are used.

This gives 657,310,216 tons as the total production exclusive of the year 1909, which is not much different from the figure originally used in the paper. Mr. DeWolf places the amount at 645,868,309 to the close of 1907. If to this is added the production for 1908 of 49,272,452 tons, the total will be 695,140,761. His figures are probably taken from the U. S. Geological Survey records, while mine are from an entirely different source. The Survey figures as a rule run higher than those of the State Reports, and it is probable that an average of the two may be taken as a representative total production of coal in Illinois to the close of 1908, which would be 660,589,262 tons, and upon a basis of 57 per cent recovery, would represent an exhaustion of 1,158,928,500 tons.

ESTIMATE OF COAL PRODUCTION IN ILLINOIS FROM EARLIEST RECORDS TO 1908 INCLUSIVE.

YEAR.	TONNAGE.	YEAR.	TONNAGE.
1833.....	5,357	1871.....	2,678,571
1834.....	6,696	1872.....	3,000,000
1835.....	7,143	1873.....	3,500,000
1836.....	8,929	1874.....	3,752,679
1837.....	11,161	1875.....	3,976,052
1838.....	12,500	1876.....	4,464,286
1839.....	13,427	1877.....	4,776,786
1840.....	15,149	1878.....	5,089,286
1841.....	31,250	1879.....	4,464,286
1842.....	51,786	1880.....	5,460,158
1843.....	66,964	1881.....	6,000,000
1844.....	107,143	1882.....	9,115,653
1845.....	133,929	1883.....	10,508,791
1846.....	147,321	1884.....	10,105,005
1847.....	160,714	1885.....	9,791,874
1848.....	178,571	1886.....	9,246,435
1849.....	232,143	1887.....	10,278,890
1850.....	267,857	1888.....	11,855,188
1851.....	285,714	1889.....	11,597,963
1852.....	303,571	1890.....	12,638,364
1853.....	334,822	1891.....	15,660,698
1854.....	343,750	1892.....	17,862,276
1855.....	357,143	1893.....	19,946,564
1856.....	366,072	1894.....	17,113,576
1857.....	401,786	1895.....	17,737,864
1858.....	437,500	1896.....	19,786,626
1859.....	473,214	1897.....	20,072,758
1860.....	650,357	1898.....	18,599,299
1861.....	598,214	1899.....	23,434,445

YEAR.	TONNAGE.	YEAR.	TONNAGE.
1862.....	696,429	1900.....	25,153,929
1863.....	794,643	1901.....	26,635,319
1864.....	892,857	1902.....	30,021,300
1865.....	1,125,000	1903.....	34,955,400
1866.....	1,410,714	1904.....	37,077,897
1867.....	1,607,143	1905.....	37,183,374
1868.....	1,785,714	1906.....	38,317,581
1869.....	1,655,357	1907.....	47,798,621
1870.....	2,343,003	1908.....	49,272,452

Dr. I. C. White has been of valuable assistance in calling attention to the disposition that has prevailed in the past to largely overestimate available fuel reserves. He considers that my estimate of 201,000,000,000 tons is too large, and I am very glad to have his opinion, as there is no one who can speak with greater authority on a subject of this character, and while he may be correct, I am unable to see my way clear to reduce the figure which I have made, because the thinning out and disappearance of seams towards the center of the basin regarding which he speaks, has been taken into consideration. It is a fact that we have in the center of this coal basin a large comparatively barren area, which is clearly indicated on my maps 1 and 2, and the coal attributable to this area is considered to aggregate 1.5 feet, upon the assumption that it is present in the lower measures in the form of small basins and isolated bodies.

I am thankful for the valuable discussion presented by Mr. DeWolf. While I have the greatest appreciation for the work of Mr. Worthen, the first State Geologist, I have found the reports of the original Survey of very limited value so far as economic problems are concerned. I realize, however, and have taken pleasure in saying that his work on paleontology is of the greatest value to students of geological problems.

I regret that it has been impossible to present more evidence supporting the conclusion that the body of coal in Williamson, Franklin, Southern Perry and Jackson counties now called No. 7, is the same seam as that known as No. 6. Both the former State Geologist Dr. Bain, and Mr. DeWolf, have for a considerable period of time believed that it was No. 6. Up to the present time, however, I have not clearly understood upon what basis such claim was made; the evidence afforded by the *Fusilina* fossil may, in my opinion, be regarded as more conclusive than the fact that each of the bodies of coal have a blue band located near the bottom in a corresponding position, because it would be impossible for two coal seams to contain a parting similar in each case without their being the same seam. It will be rather hard for some people, I dare say, to accept the theory that what has been regarded as two different beds of coal are the same, in view of the different manifestations of pyrites in the two beds as well as for other reasons. I am quite anxious, however, to accept the theory that the so-called No. 7 bed of coal is in reality No. 6, and hope that

in the near future the Geological Survey will publish more matter bearing on the subject, so that we may be in a position to accept the correction. The analysis of groups A, B, C and D submitted by Mr. DeWolf, giving B. t. u. values on the basis of ash, water and sulphur free coal as follows:

	Ash, Water and Sulphur free B. t. u. Average
Group A	
Coulterville to Duquoin along I. C. Ry.	14,385
Group B	
Perry County east of Duquoin	14,400
Group C	
Eastern part of Jackson County	14,644
Group D	

Northwest corner of Williamson County 14,589
does not prove the matter, notwithstanding that it shows the B. t. u. west of Duquoin in seam No. 6 to be within 15 units of that to the east in seam "7." Sulphur should not be excluded because it is one of the combustible elements just as is hydrogen or carbon; in fact it is in the sulphur content that the real difference lies if there be any. The proper comparison is that of the heating value of the pure coal and on this basis Mr. DeWolf's B. t. u. values are as follows:

	Seam No.	Heating power in B. t. u. per pound of Pure Coal
Group A		
Coulterville to Duquoin along I. C. Ry.	6	14,157
Group B		
Perry County east of Duquoin	"7"	14,353
Group C		
Eastern part of Jackson County	"7"	14,509
Group D		

Northwest corner of Williamson County "7" 14,526
This shows the value of the southern end of the No. 6 coal bed west of Duquoin as low in heating power as at its northern end at Virden. Also instead of an agreement, there is a decided difference in the heating power to the east and west of Duquoin. My conclusion is, that instead of 14,157, the pure B. t. u. value of No. 6 seam at Duquoin is 14,360. On this basis, accepting Mr. De Wolf's figures for Groups B, C and D and mine for Group A, we have the following:

	Seam No.	Heating power in B. t. u. per lb. of pure coal, according to De Wolf and Bement
Group A		
Coulterville to Duquoin along I. C. Ry.	6	14,360
Group B		
Perry County east of Duquoin.....	"7"	14,353
Group C		
Eastern part of Jackson County	"7"	14,509
Group D		

Northwest corner of Williamson County "7" 14,526
which would indicate that the evidence afforded by the heating power value shows a similarity between seam Nos. 6 and 7.

While I have given the pure B. t. u. value of the Williamson and Franklin county field, which also includes the eastern portions of Perry and Jackson counties as 14,500, there is an opportunity to establish more exact values in different portions of the field, because it is a fact, that the heating power increases from north to south and also from west to east. In reality, the B. t. u. value over the entire basin increases from west to east, so that the corresponding seams in Indiana have a higher heating value than in Illinois.

Relative to the amount of coal originally present, in the preparation of my figures, areas given in Table No. 3 were carefully measured on a very large map (some 25 feet long, on a scale of $\frac{1}{2}$ inch to the mile), and these areas were carefully computed from what may be designated as known thicknesses, as the thickness for the areas Nos. 1 and 4, inclusive, are quite well known. In the case of the unknown area of 10,199 square miles, which is the territory in the center of the basin, it was assumed that the coal would average a thickness of 1.5 feet for the entire area, not as regular persistent seams, but in isolated bodies, which might range in thickness to several feet, and workable as separated and distinct beds, rather than as recognized seams. Or in other words, the areas given in table No. 2 are those shown on map No. 1. No account was taken of coal which might lie above these seams, because I felt there was no evidence that it ever would be of much commercial importance, but it was recognized that coal having some value is located below the beds given in areas 1 to 4 of Table No. 3, therefore it was assumed that lying below these areas, there were beds having an aggregate thickness shown in Table No. 4. The basis upon which my estimate has been made, is one which excludes everything lying above the important seams, and including everything below. In all probability, it may be considered practically as an estimate of the total amount of coal present. If Mr. Campbell's figures included all coal measuring 20 inches and over, his conclusion is one which would probably indicate a still larger difference in our estimates than the figures of 240,000,000,000 and 201,000,000,000. As Mr. De Wolf's estimate is based on the amount of workable coal, I am inclined to consider that he and I are in fairly close agreement in figures, and that Mr. Campbell's is much too large.

In connection with the migration of the center of production to the south, into the region of thick coal, it was not my intention to imply that the thinner coals were not of importance, or to base any conclusions on the amount of coal shipped away from the state as compared to that used at home, and possibly the matter has not been made clear. It was my idea to emphasize the fact that on a strictly competitive basis the thick coal would monopolize the entire output because of lesser cost of production, and that the reason why the thin coal to the north and the medium coal west of the Illinois river had continued to increase in output, although on a small scale, was because of certain features of the transportation situation. For example, there are railroads which reach these territories, having an outlet to the north

and west, which do not reach thick coal areas, and it is for this reason that these fields continue to flourish. If a difference in the cost of production did not exist, the center of output would be at the north end of the state, and the extensive southern development would not have taken place. To illustrate,—the Chicago & Northwestern Ry. obtained an important portion of its coal supply from mines at Spring Valley in Bureau county in the Northern Field, where the seam has a thickness of 3.5 feet. Later, it began hauling coal from the southern end of Macoupin county in seam No. 6 which has a thickness of 8 feet, and in order to do so, it was necessary for its trains to pass over the Macoupin County Ry. from Benld to the town of Girard, where they transferred to the tracks of the Chicago & Alton Ry., and again at Peoria, to a branch line of the Chicago & Northwestern, which joined the main line in the vicinity of the Spring Valley mines. This is going to considerable trouble to pass by the mines in thin coal to reach those in thick, and is a decided case of carrying coals to Newcastle. Should the Federal Government step in, as it may some day, and require the removal of all coal in mining, the advantage of the thick over the thin seams will be lessened, of course.

To me, personally, Mr. De Wolf has made a criticism regarding my statement concerning the buried valley which extends from Madison across Montgomery and Christian counties. He is disposed to consider it as an erosion during the carboniferous period, or at least, that part of it was so formed. His argument, of course, is quite reasonable, because of the great depth. My statement was based especially on the results of borings made north of the town of Sorento in Montgomery County. But the matter is quite an interesting one from a geological standpoint, and it would be desirable to have more light on it. It has recently been reported that when the shaft at Assumption was sunk, that the "Pana" coal (seam No. 6,) was found at the expected depth, but so thin that it could not be mined. Assuming that this statement is correct, the location of this shaft would mark the edge of the coal bed. On this basis I have made a detailed map of the locality, Fig. 4, which shows railroads and towns with a change in the boundary of this valley, assuming that the bed of No. 6 coal extends as far north as the town of Assumption. If this assumption may be accepted as correct, the edge of the coal bed from the northeast corner of Madison county to this point is defined with a high degree of accuracy. The data, however, upon which the extension into Madison county is based is very meager. The other boundary of the bed is indicated with a high degree of accuracy from Clarksdale in Christian county to the locality of Binney in Madison county.

Mr. S. A. Shafer, General Manager of the Assumption Coal & Mining Co. has dug up for me a partial record of the strata passed through in sinking the shaft at Assumption in Christian county. The original records, it appears, were lost in a fire some years ago, and the data herewith presented is from partial memoranda made by one

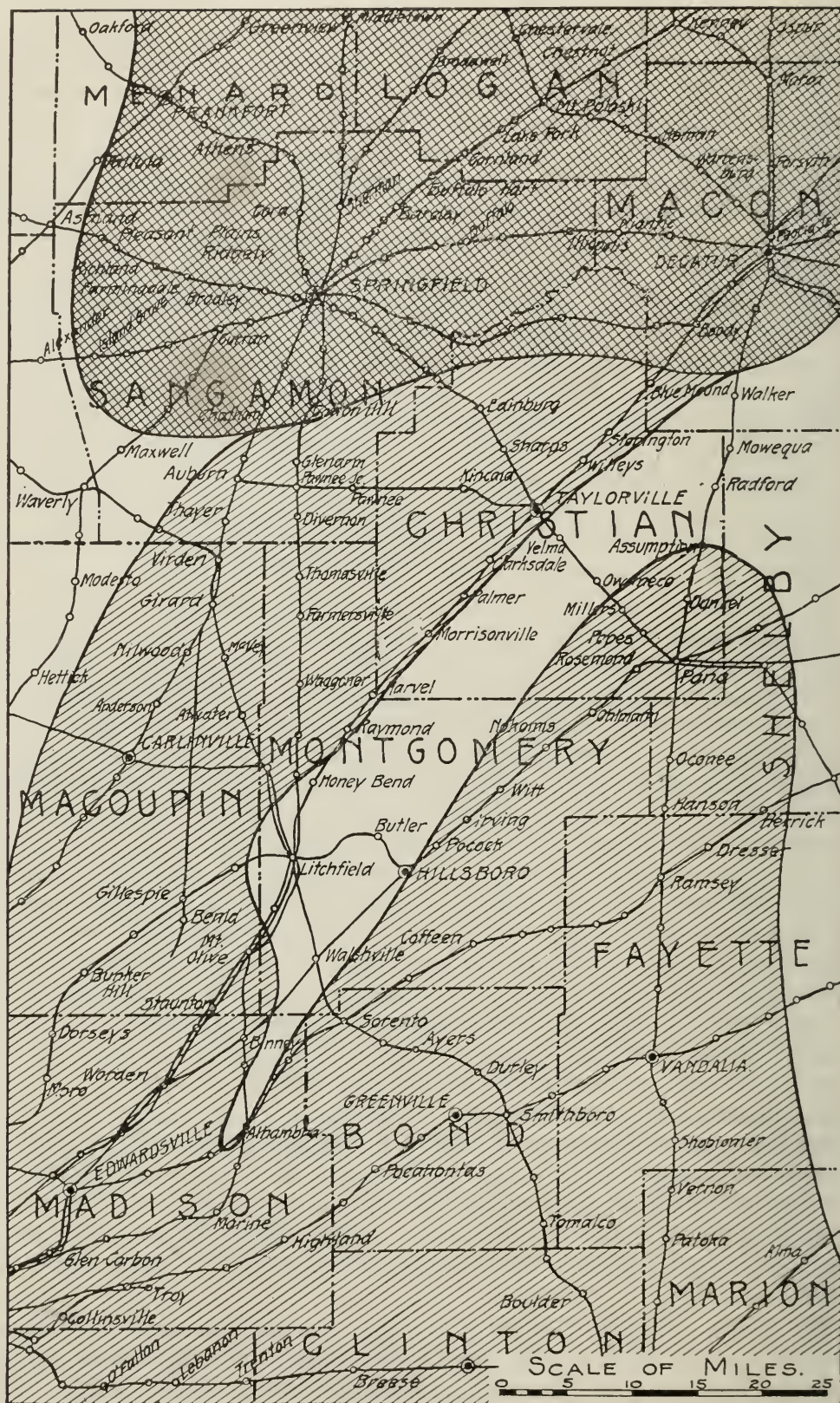


FIG. 4.
Location of Great Eroded Valley Cutting Through No. 6 Coal Seam.

of the stockholders of the Company. It, however, does not begin until at a depth of 538 feet, in which the seam of coal considered as No. 6 is 1 ft. 8 in. thick. There is, however, some question in my mind whether it is this seam or not. because at Pana, which is about thirteen miles further south, it is at a depth of 720 feet. At all events, I have changed the boundry of the No. 6 seam in the territory to the north of Pana, so that it extends to the town of Assumption, assuming, that the conditions at this point are similar to those at Raymond, Hillsboro and Palmer, as well as borings north of the Big Four Ry. in Montgomery county, all of which points appear to very clearly mark the boundary.

PARTIAL LOG AT ASSUMPTION, AS REPORTED

	Thickness		Depth		
	Ft.	In.	Ft.	In.	
Chocolate shale.....	6	0	538	4	
Blue shale.....	25	6	563	10	
Black shale.....	2	0	565	10	
Coal and slate.....	..	6	566	4	No. 7 Seam
Conglomerated lime and clay.....	12	0	578	4	
Lime rock.....	3	0	581	4	
Sand stone.....	20	0	601	4	
Blue sand shale.....	23	0	624	4	
Brown sand shale....	4	0	628	4	
Lime stone.....	1	0	629	4	
Coal	1	8	631	0	No. 6 or Pana Seam
Fire clay and boulders	6	0	637	0	
Sand stone.....	10	0	647	0	
Fire clay and rock....	7	0	654	0	
Black shale.....	2	0	656	0	
Coal	..	2	656	2	No. 5 or Moweaqua Coal
Fire clay.....	10	0	666	2	

To Mr. E. E. R. Tratman, I would say that it is, of course, true, that with conditions of increasing demand and decreasing supply, it will be possible to operate seams which are now of minor importance, but the fact still remains that the advantage lies with the thick coal, therefore its conservation and economical exploitation is a matter constantly increasing importance, with the result that the value of the thick coal will be much greater in the future than it is at present.

Mr. George S. Rice has presented a valuable and very welcome discussion. It is a fact, as he suggests, that attention should also be directed to the reckless use of explosives in other counties than Franklin. It was not the intention to intimate that this trouble was confined to Franklin county, although it is much worse there than elsewhere.

I think, in all probability, my manner of expression may have led to misunderstanding, as it was not my purpose to intimate that only one-half of one per cent of the area of the Coal Measures of the State contained coal adaptable for competition, but that in the par-

ticular instance mentioned, it was a fact that the territory which could be purchased and that was suitable for operation under conditions in this case, was one-half of one per cent, and that a large portion of territory which would otherwise have been suitable, had passed out of the hands of original owners.

Mr. Williams has presented useful discussion. In reference, however, to the difference between the figures for ash given by me for Pocahontas coal as compared with the West Virginia Geological Survey Reports, I do not think it is due to difference in method of sampling, but rather to a variation in the quality of coal. The "Pocahontas" and "Smokeless" which reach Chicago, are coals variable in character, rather different than that which has been exploited on the seaboard. As a matter of fact, however, 5.5% is probably a little lower than good Pocahontas will probably average; 6% would be a better figure.

Mr. Taylor, I observe, gives me credit for compiling a mass of data. I have not considered the paper to be in the nature of a compilation. It is true that a very large amount of labor was expended upon the gathering and putting together of various information, but to my mind the most important feature of the work is the conclusions which have been drawn, based almost altogether upon many years of personal observation and experience.

I am very glad to have assistance in arriving at conclusions relative to coal values and his contributions are of value.

Mr. Taylor is in the business of testing coal for those buying under contract, wherein the quality of the fuel is guaranteed, a reduction being made in the price if it drops below, and a bonus being paid if it is above the value specified. I note that he criticises my B. t. u. value for Saline county coal, and in this connection it may be said that we had at the time serious controversy relative to the pure B. t. u. value of Williamson county coal, it being my contention that it should be considered as 14,500, although some tests by the U. S. Geological Survey on mine samples, gave a figure somewhat higher. At the time a very large quantity of Williamson county washed coal was being sold under guarantee, and the larger part of it was earning a bonus, because its quality was superior to the guarantee, although the B. t. u. value accredited to it on a pure coal basis, averaged only about 13,300, and had the proper value been employed, it would have considerably increased the bonus paid to the dealer, and I am now glad to find that Mr. Taylor in his table giving B. t. u. values of dry coal, which are based upon the same per cent of ash as given in my table 8 in comparison with dry B. t. u. values, credits the Williamson and Franklin county field with 12,788 B. t. u.: When calculated to a pure coal basis it becomes 14,558, higher by 58 B. t. u. than I ever demanded, and it gives me great satisfaction to know that the controversy has at last been settled, although I regret that there has been such a large money loss in delivery under these contracts on account of the low B. t. u. by which they were valued. These low valuations

have been very largely corrected through the use of the Mahler calorimeter. Therefore referring to my figure for Saline county B. t. u. and the criticism thereof, we are confronted with a similar condition to that prevalent during the time that a lower value was employed for Williamson county, which is, that the Saline county coal now being sold under a guarantee is already earning a bonus, and the use of a higher B. t. u. value would still further increase the amount of money the consumer pays for it above the price at which it could be purchased if not sold under a guarantee contract. I am satisfied with my own figures on the Saline county coal, as the work was conducted with great care and carefully checked, the results being based on a large number of samples, the greater portion of which I took myself after an inspection of all the mines on the Big Four Ry. I am unable, however, to offer evidence from any other source concerning the value of Saline county coal, but am able to quote Prof. N. W. Lord of the University of Ohio, on the Hocking Valley coal, which is arranged in corresponding columns with my figures on the same fuel:

	Hocking Valley Coal.	
	Values According to N. W. Lord	Values According to A. Bement
Moisture	7.55	7.88
Ash in dry coal.....	6.33	6.40
Heating power in B. t. u. per pound of pure coal..	14,446	14,341

The above table does not show a serious disagreement.

In reference to the B. t. u. value of seam No. 2 in the Wilmington field, I am inclined to agree with Mr. Taylor. At all events, I consider his value for this locality superior to the one that I used. For the figures of the analysis in the Wilmington, Northern and Peoria and Fulton fields, I am indebted to the State Geological Survey, as I felt that its figures would be more comprehensive than mine, in view of the fact that my work has been more especially in the thick coal areas, and concluded that I had best use the Survey figures, and I am sure the one suggested by Mr. Taylor for the Wilmington field is more nearly accurate, as it corroborates my experience, which would change the pure B. t. u. value from 14,201 to 14,462.

The table which he has offered as representing B. t. u. values for the different fields on a 10% ash basis, would have been more useful, if presented on a pure coal basis, therefore I have made Table A, giving pure B. t. u. values for each of the fields, which will enable one to calculate therefrom B. t. u. values on a dry and moist basis, by reducing the heating power in proportion to the ash and moisture present. Thus if the moisture and ash are each 10%, multiplying the pure B. t. u. value by 0.80 will give the moist coal B. t. u. This table of factors has never before been published, and it is useful in determining B. t. u. when ash and moisture have been determined, thus eliminating the necessity for the use of a calorimeter.

Mr. Taylor has referred to a scheme of valuing coal according to tables, but he does not present it clearly, therefore I will explain as

follows: Prof. S. W. Parr on October 3rd, 1906, in a discussion to my paper on the Testing of Coal, at page 672, Vol. XI of the Journal of the Western Society of Engineers, first introduced the matter of a possible loss from the ash content by the volatilization of inert matter. It was at the time presented as an argument against my proposition to treat the pure coal value as a constant for any seam or definite locality in any seam. Following this, Mr. W. F. Wheeler in the Journal of the American Institute of Mining Engineers, Vol. XXXVIII, p. 621, under the title of Pure Coal as a Basis for the Comparison of Bituminous Coals, presented the most complete discussion of the matter which has been thus far published. While Mr. Wheeler's paper was prepared and received by the Society during the latter part of 1906, it was not published until the summer of 1907. Mr. W. Brinsmaid who had been employed in the chemical laboratories of the State University and Geological Survey under Prof. Parr, and who worked with Mr. Wheeler, resigned his position in July, 1907, to accept one with the Fuel Engineering Co. While in its employ he is credited with having continued Prof. Parr's inquiry, and has published in the Journal of Industrial and Engineering Chemistry of the American Chemical Society, Vols. I and II, a supposed explanation of the methods employed in preparing the tables to which Mr. Taylor refers. He, however, fails to furnish data to support the argument presented; thus while a great deal has been said concerning the utility of the tables to which Mr. Taylor makes reference, no explanation of the means employed in their construction has been offered. My own contribution to this subject, in its reference to the paper by Mr. Wheeler, will be found in the Transactions of the American Institute of Mining Engineers, Vol. XXXIX, p. 800. The scheme proposed by Prof. Parr, and which Mr. Taylor is now exploiting, is one having academic value as bearing on the study of problems in the laboratory. Its application, however, in commercial testing is doubtful, or at best untried, and for that reason my original contention for established B. t. u. values applying to a definite locality, such as given in Table A, is much to be preferred, and if further refinement is demanded, similar value for different grades of coal as lump, mine run, or screenings may be adopted.

No.	Coal Field Name	Seam No.	Heating Power in B. t. u. per pound of Pure Coal
TABLE A.			
1	Rock Island.....	1	14,375
2	Northern	2	14,438
3	Wilmington	2	14,462
4	Peoria and Fulton.....	5	14,330
5	Grape Creek.....	6	14,140
6	Springfield	5	14,350
7	Virden	6	14,145
8	Pana	6	14,225
9	Central Illinois.....	6	14,240

No.	Coal Field Name	Seam No.	Heating Power in B. t. u. per pound of Pure Coal
10	Centralia	6	14,390
11	Duquoin	6	14,360
12	Williamson and Franklin.....	6 or 7	14,500
13	Big Muddy.....	2	15,075
14	Saline	5	15,048

Prof. Breckenridge has presented an elaborate discussion which I very much appreciate, although it does not appear that his data disproves the statement that, as a general proposition, the quality of coal seams increases with depth or from north to south. There may be grounds for questioning what is meant by my expression—general proposition. Therefore I will say that the meaning intended to be conveyed was, that in the majority of instances these were the facts. Take the matter from the standpoint of lower and upper seams at the southern end of the State, for example; in this territory seams Nos. 2, 5 and 7 are worked, and the heating power value of the two lower ones are higher than No. 7. Or, take the northern portion of the State as between the lower seams on the basis of general quality, per cent of moisture and ash content, and it is very clear that the seams of the lower measures are the best. Or again, if we follow the heating power of the No. 6 seam from North to South, on the pure B. t. u. basis, it ranges from 14,140 to 14,390 at Duquoin and in Williamson county and, assuming that the "No. 7" in Williamson and Franklin counties is a continuation of the large body of No. 7 coal, it is 14,500. Or compare any B. t. u. value at the north end of the State with that of Jackson or Saline county, or with an average of Jackson, Saline and Williamson counties, and it will be at once apparent that my statement is true. Even taking the Williamson and Franklin county field, F. W. Wheeler in *Trans. American Institute of Mining Engineers*, Vol XXXVIII, p. 628, states that the decrease in B. t. u. from Marion in Williamson county to Ziegler at the North in Franklin county, is 319. Again, at Springfield, the B. t. u. value of the No. 5 seam is 205 B. t. u. higher than the No. 6 seam in the same locality. It is no doubt true, that there may be exceptions to this general tendency. I have always believed that there was, but failed to see any evidence that, as a general proposition, my contention is in error, the only exception I know of being quoted by Mr. De Wolf. In the instance he mentions, of coal mined in Shelby county from what is called seam No. 14, the ash in the dry coal is given as 7.85 and the B. t. u., 13,234, which when calculated to the pure coal basis becomes 14,361, indicating a good quality, slightly superior to that of seam No. 5 at Springfield.

Prof. Breckenridge has also given results of tests of coal from shafts of different depths. Assuming that the boiler tests which have been quoted are to be depended upon for data of value in this connection, attention should be directed to the fact that depth of shaft would not give the basis required. For example, shafts in seam No. 6

range to over 800 feet deep, yet they are in the same seam. As a matter of fact, in most instances, the lower seams where operated, are not reached by deep shafts; thus Saline county in No. 5, which is one of the low seams, or again in No. 2 in Jackson county, are reached by comparatively shallow shafts, while No. 6 seam, the poorest in quality, is operated on a considerable scale by shafts deeper than 700 feet. Thus it appears conclusive that no evidence has been offered controverting my contentions. Even were I in error, tests under boilers could not be depended upon to show it, because a test with a boiler is something in which so many variables enter, that it would be impossible to discover the influence of the coal itself, or determine whether the peculiarity of the result was due to it or something else; or again, percentages of moisture or ash necessarily present themselves as variable and for this reason the lots of coal that happen to have been used would also necessarily be variable. The only way to show whether or not I am in error, would be to present B. t. u., moisture and ash values for the various seams.

The matter, however, should not be dismissed without some detailed examination of his tables and diagrams, therefore referring to Table No. 1, it appears that the ash given for La Salle, Franklin, Williamson and Saline counties, and the moisture for Williamson and Franklin are lower than other counties; decidedly so, as to the moisture content. Again, the B. t. u. is superior in the case of La Salle, Franklin, Williamson and Saline counties. It is these counties in which the lower seams are operated, and instead of this table disproving my statement, it is more in the nature of a corroboration.

Fig. 2 gives a higher heating power value in the northern and southern end of the State than in other portions, or in other words, in La Salle, Williamson, Franklin and Saline counties. If this diagram shows anything, it corroborates my statement.

Fig. 3 indicates a rapidly decreasing moisture content going South, which is in accordance with my claims.

Fig. 4 shows a decidedly lower ash percentage in the North where seam No. 2 is worked. Likewise a lower ash content in the southern end compared to the center of the state.

Diagram No. 7 shows a moisture content much lower in shallow shafts than in deep ones. This again corroborates my contention because the shallow shafts are located near the edge of the basin and reach the lower seams, more especially in the southern part of the State.

I make no reference to some of the other diagrams because they can have no bearing on the question at issue. For example, diagram No. 8 shows ash percentage in coal as fired under a boiler, from mines of different depths. The fuel used in these tests is a composition quite different from that present in the seam before mining, and might just as well be offered as evidence of the character of preparation as anything else.

BOILER CORROSION AS AN ELECTROCHEMICAL ACTION

PROF. C. F. BURGESS, UNIVERSITY OF WISCONSIN.

Presented Before the Electrical Section, January 15, 1909.

Iron and steel under most influences to which it is exposed, undergo deterioration in various ways. The most prominent type of deterioration is that designated as corrosion.

In analyzing the causes of and remedies for corrosion we are drawn to the conclusion that the term corrosion is not the name of one disease, but it is a generic term, covering a large number of diseases with which iron may be afflicted.

The particular uses to which iron is put has a marked influence on the kind of corrosion which it will develop. Thus we have certain diseases contracted by iron pipes through association with electric railway lines, which diseases are different both as to cause and effect from those encountered in steel smoke-stacks. We have one kind of corrosion of galvanized fence-wire which is different from that produced by iron exposed to sea water.

Dr. Cushman of the Department of Agriculture has asserted that all kinds of corrosion of iron, whether it be on pipes buried in the city of New York or on the plains of North Dakota; of fence wire or on battle ships, is due to one and the same cause—electrolytic action, or, galvanic action, as it is more commonly termed.

This is perhaps a radical assertion, but it is one to which we can bring much experimental data and information in support of its accuracy. It is this fact that furnishes the justification for presenting this paper on iron corrosion to the Electrical Section of the Western Society of Engineers.

Your attention is being called particularly to corrosion in steam boilers, and to the possibility of its being due to electrolytic action. If this be true, then the prevention of boiler corrosion becomes a problem worthy of study by electrically trained men.

It is not a modern idea that corrosion in steam boilers may be attributable to electrolytic action, since based upon this supposition, we have the frequently suggested, though less commonly practiced, use of zinc to prevent such corrosion.

The influence of inequalities of temperature and of galvanic action resulting from this and other causes, have been classified among those which are considered to be of minor importance, but it is upon these factors that special emphasis is to be paid here, due to the belief of the writer, founded upon experimental observation, that if electrolytic action were entirely absent, or could be exactly neutralized, there would be practically no internal boiler corrosion to be encountered.

To produce electrolytic action, we must have an electrochemical system, consisting of two different metallically conducting electrodes

at differences of electrical potential, and making contact with an electrolyte. The system becomes active when the two electrodes are connected together, furnishing a metallic path as well as an electrolytic path for the flow of current. It is a fundamental law of electrolysis that the anode is subjected to an oxidizing action and the cathode to a reducing action. The oxidation at the anode must be considered in its general sense, that is, the union of the metal with oxygen or some other electro-negative element or radical. The result of this oxidation may be the formation either of a soluble or an insoluble material, and without taking up a detailed consideration of the factors which influence this solubility or insolubility of the resultant product, it may suffice to state that iron as an anode in waters commonly employed for boiler purposes, and with the low current densities which are encountered, the iron will form, in the main, soluble products, such as iron chloride, sulphate, nitrate, and the like.

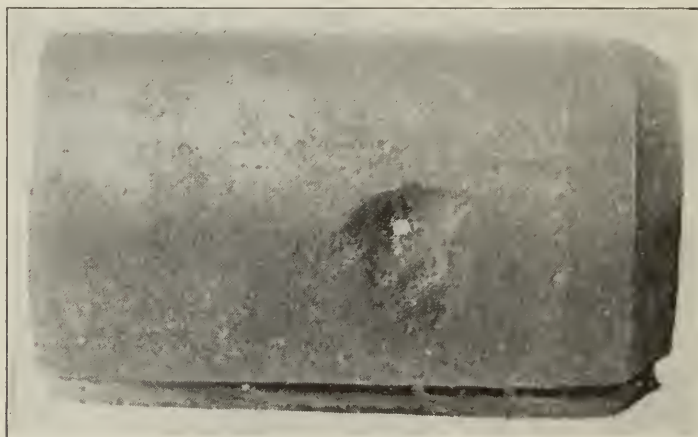


Fig. 1. Pitting of a Boiler Tube

In the locomotive boiler which will be taken as our typical case for examination, we have one continuous metallic structure enclosing a body of water which constitutes an electrolytic conductor. To find in such a boiler an electrochemical system, we must find differently charged electrodes which are in metallic contact. That there are such various combinations will be pointed out.

Any metallic conductor making contact with an electrolytic conductor sets up at such point of contact a potential difference, the amount depending upon the nature of the two conductors. Thus we have zinc setting up a higher potential against the solution than will iron against that same solution, and were these two metals to be brought into metallic contact, electrolytic action will result, the current being proportional to this difference of potential and inversely as the resistance, providing, of course, there is no polarization to act contrary to the primary electro-motive force.

In the electrochemical series of elements we have a classification of materials according to the potentials which they will set up,

the electro-positive ones becoming the anode as against any substance lower in the series. With a piece of zinc in contact with iron and a common electrolyte in contact with both, the zinc becomes the anode and subject to corrosion, and the more electro-negative iron becomes the cathode, and is thereby protected from corrosion. On the other hand, with a particle of carbon or cinder or other material electro-negative to iron, the iron becomes the corroding anode material, and it is upon this basis that the common explanation is given for the production of certain pitting attributable to the presence of a small particle of cinder or black oxide scale or similar material which makes the iron immediately around it, the anode.

It is not an uncommon boiler practice to insert a copper ferrule between the tube and the tube sheet to insure a tight joint. This constitutes a voltaic couple, the portion of the copper in contact with the boiler constituting a cathode and the surface of the iron in its neighborhood the anode.

To have other electrolytic couples it is not necessary to assume the presence of such other electro-negative metal or to the influence of embedded cinders or carbon, or to the segregation of impurities in the iron. Iron itself may set up such couples, depending upon its previous physical treatment, pressure of strains, and inequality of temperature.

Upon a suggestion from Mr. Walter Alexander, of the Motive Power Department of the Milwaukee shops, C. M. & St. P. Ry. Co., some investigations were begun about two years ago in the chemical engineering laboratories of the University of Wisconsin, to study some of the peculiar types of corrosion which are encountered in the practical operation of locomotive boilers.



Fig. 2. Grooving of a Boiler Tube

The peculiar types of corrosion to which attention was particularly called were pitting of tubes, most frequently found on the lower side of the bottom tier of tubes; also the grooving, found most generally just within the tube sheet at the front end of the boiler.

After a large amount of preliminary work which need not be described here, marked evidence was found, tending to support the supposition that electro-motive forces are developed within boilers, due to the inequalities of temperature between tubes and shells, and also that such electro-motive forces were of sufficient magnitude to cause the passage of enough electric current to produce appreciable corrosion within a short time.

It was found that the electro-motive forces varied with the kind of feed-water employed, and with varying conditions within the boiler; and, naturally, the variations in the electric currents which were established, varied in greater degree, due to the varying electrical conductivity in different kinds of feed water.

It appeared desirable to conduct these electrical measurements upon a locomotive boiler under actual conditions of service, but such tests have had to be postponed until laboratory investigations had been made, and it is hoped that the larger scale investigations will be conducted during the coming year.

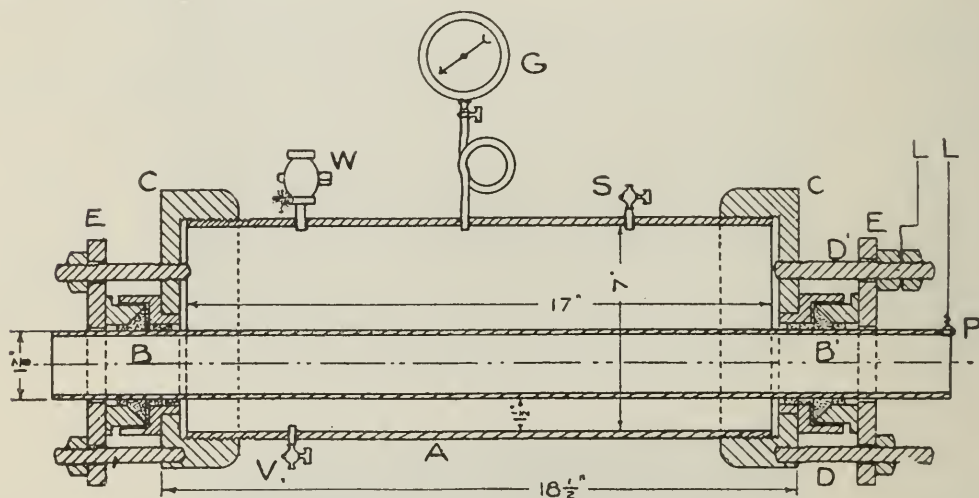


Fig. 3. Apparatus for Studying Boiler Corrosion

The latest type of laboratory apparatus upon which most of the observations have been made is illustrated in Fig. 3. This consists of an iron pipe "A," 7 inches in diameter, and 17 inches long, closed by iron caps screwed on the ends. "B" and "B'" are stuffing boxes, placed below the center of the caps through which the pipe "P" passes. The purpose of this stuffing box is to insulate the pipe from the steel cylinder, at the same time allowing this joint to stand a high steam pressure. Asbestos packing was found to serve this purpose admirably. The cylinder was fitted with a steam gauge and steam cock for the release of pressure, and another opening for the introduction and drawing off of water and sediment. Heat was applied to the apparatus by means of a blast flame inside of the smaller tube.

Electrical connections, L. L., were made between the inside and outside tubes through the electrical measuring instruments, consist-

ing of a mil-ammeter and a mil-voltmeter. A large number of tests were made by means of this apparatus, employing various kinds of boiler water and operating under a variety of conditions as regards pressure, rapidity of heating, cleaning out of the apparatus, etc.

In each of the test runs which will be described here, the inner tube and the interior of the larger tube were thoroughly cleaned prior to each run or series of runs on a given feed water. There was introduced each time 6,000 c. c. of water, always leaving a given gas space of a volume of equivalent about 2,000 c. c.

The experimental work, and the compilation of results, was done by Mr. J. H. Thickens.

The various test runs which are referred to here are designated by Nos. 12, 13, 14, 15, 16, 17, 18, 19, 24 and 25. The results of the tests are given without attempting to explain all of the features or peculiarities noted in connection with the data obtained. This lack of explanation we shall have to attribute to inability rather than to neglect, and it is hoped that further investigation which is to be carried on, and that suggestions which may be offered by others interested in this work, may make it possible to bring about a clearer understanding of the various phenomena which are involved.

As to test No. 12, curves are given which show the variation of current between the inner and outer tube with variations in time, temperature and steam pressure within the experimental boiler. Distilled water was employed, containing 3 grams of amidol as a reducing agent, to the 6,000 c. c. of solution. The distilled water employed in these and other experiments was produced under conditions such that it became aerated, and the presence of air is undoubtedly an important factor. Upon introducing the water it was noted that there was a momentary flow of current of 0.075 amperes, which, during the first few minutes decreased rapidly and then more slowly, falling to 0.0085 amperes at the end of 260 minutes. The initial electro-motive force which caused this flow of current may perhaps be attributed to differences in the composition or previous treatment of the iron, constituting the inner and outer tube respectively, and the decrease of the current which is here noted, may be due to polarization effect, both at the anode and at the cathode.

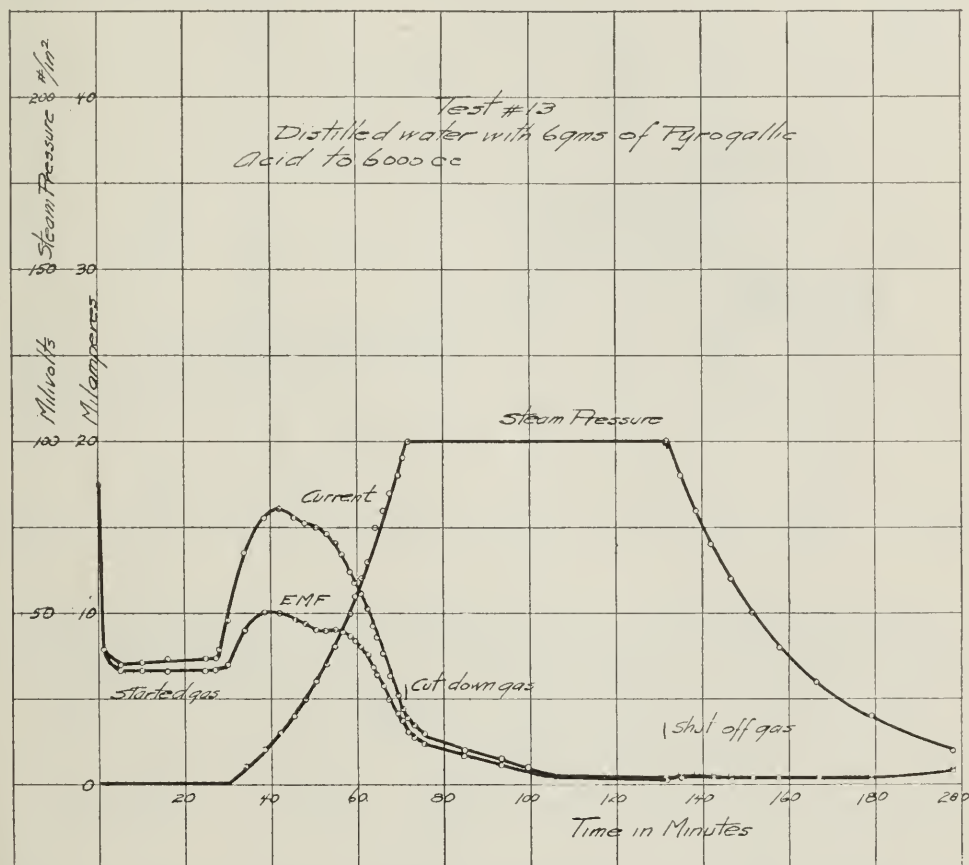
In all of the curves, it is to be noted that the current and electro-motive force when plotted above the base line, indicate that the inner tube is the anode, while, when they fall below, indicate that the outer tube is the anode.

At the end of 260 minutes, heat was applied to the inner tube and the current rapidly increased to a maximum of 0.067 amperes, which maximum point was reached somewhat before the maximum steam pressure of 100 lbs. per sq. in. had been attained. After this the current fell off, rapidly at first and then more slowly, until after 440 minutes the source of heat was removed, when the current rose for an instant and then fell off more rapidly.

It does not appear from these curves that the amount of current

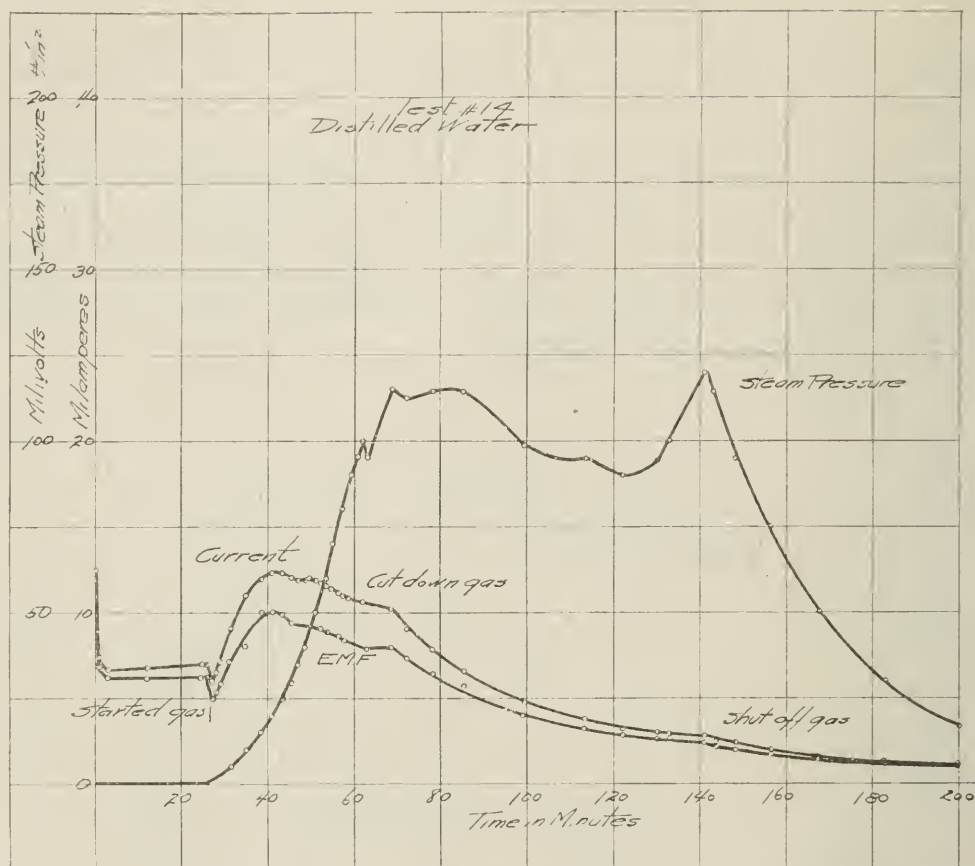
is a function of the temperature alone or of the differences of temperature, but it appears that it is also dependent upon the amount of some constituent in the electrolyte itself.

In test No. 13, 6 grams of pyrogallic acid were added to the distilled water, and values of both the current and the open circuit electro-motive force were obtained during the progress of the test. In this case, after the heat was applied, the current and electro-motive force attained maximum values considerably before the maximum steam pressure was reached and the values then decreased rapidly, until they became almost negligible.



Test 13. Showing effect of Acid in the Electrolyte, on the Current and Electro-motive force.

Test No. 14, was similar to test No. 13, with the exception that distilled water alone was employed, and in this we have values of electro-motive force similar to those in the previous experiment, but the corresponding amounts of current were materially less, due probably to the decreased conductivity of the solution. In this experiment the steam pressure was not kept at a constant value, but was allowed to vary through a wide range to determine what influence, if any, the steam pressure might have on the current and electro-motive force values. The conclusion seems to be that there is little, if any, such influence.



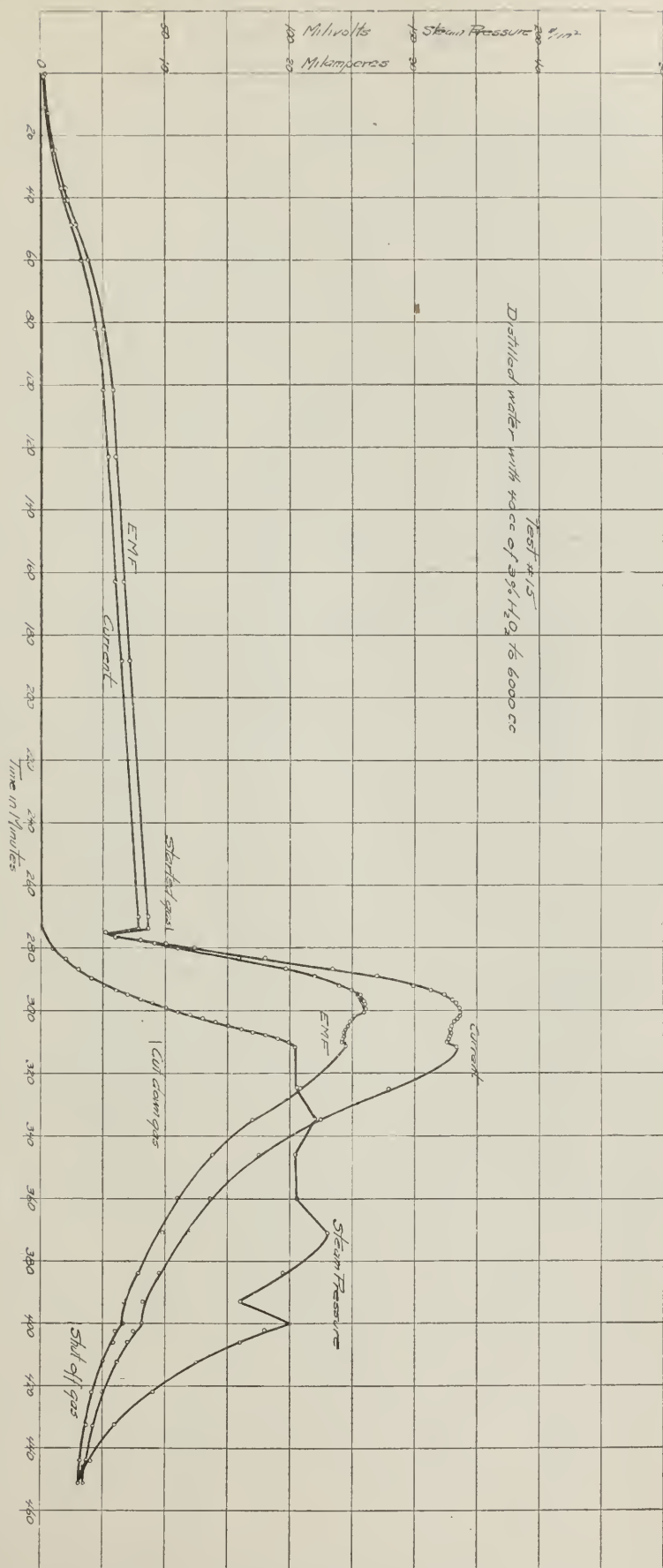
Test. 14. With Distilled Water, Showing Variations in Current and Electro-motive Force.

To test the influence of an oxidizing agent in the electrolyte was the purpose of test No. 15, for which a solution containing 40 c. c. of 3% hydrogen peroxide were added. This solution was found to be slightly acid. The increased corrodibility of this solution is shown by the increase of current and electro-motive force curves.

That the corrosion is proportional to the area included in the current curve, and that such corrosion results in a diminution in the corroding agent, is shown by test No. 16, which is a repetition of No. 15, in which the apparatus was allowed to cool down and stand for 16 hours before beginning this test, the same solution as used in test No. 15 being kept in the apparatus. The current in this case was much smaller than in the previous run. After cooling down and again heating, the current curve is still smaller.

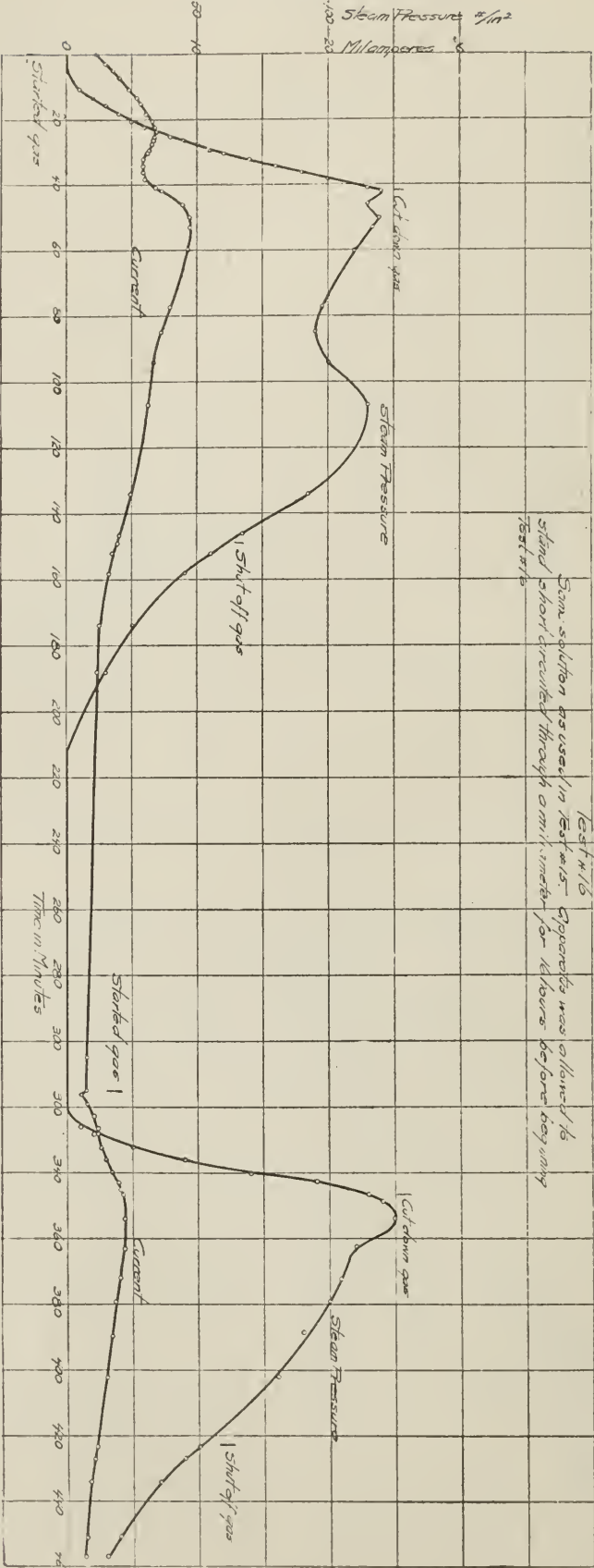
In test No. 17, distilled water was used, containing 1.82 grams of soda ash to the 6,000 c. c. of water. This is equivalent to about 1 pound per thousand gallons, and is an amount frequently used in locomotive boiler practice.

The most noticeable influence of the effect of this soda ash is to increase the conductivity of the electrolyte and thus increase the current flow, although it is also noted that the electro-motive force is somewhat higher than is found with the untreated distilled water.

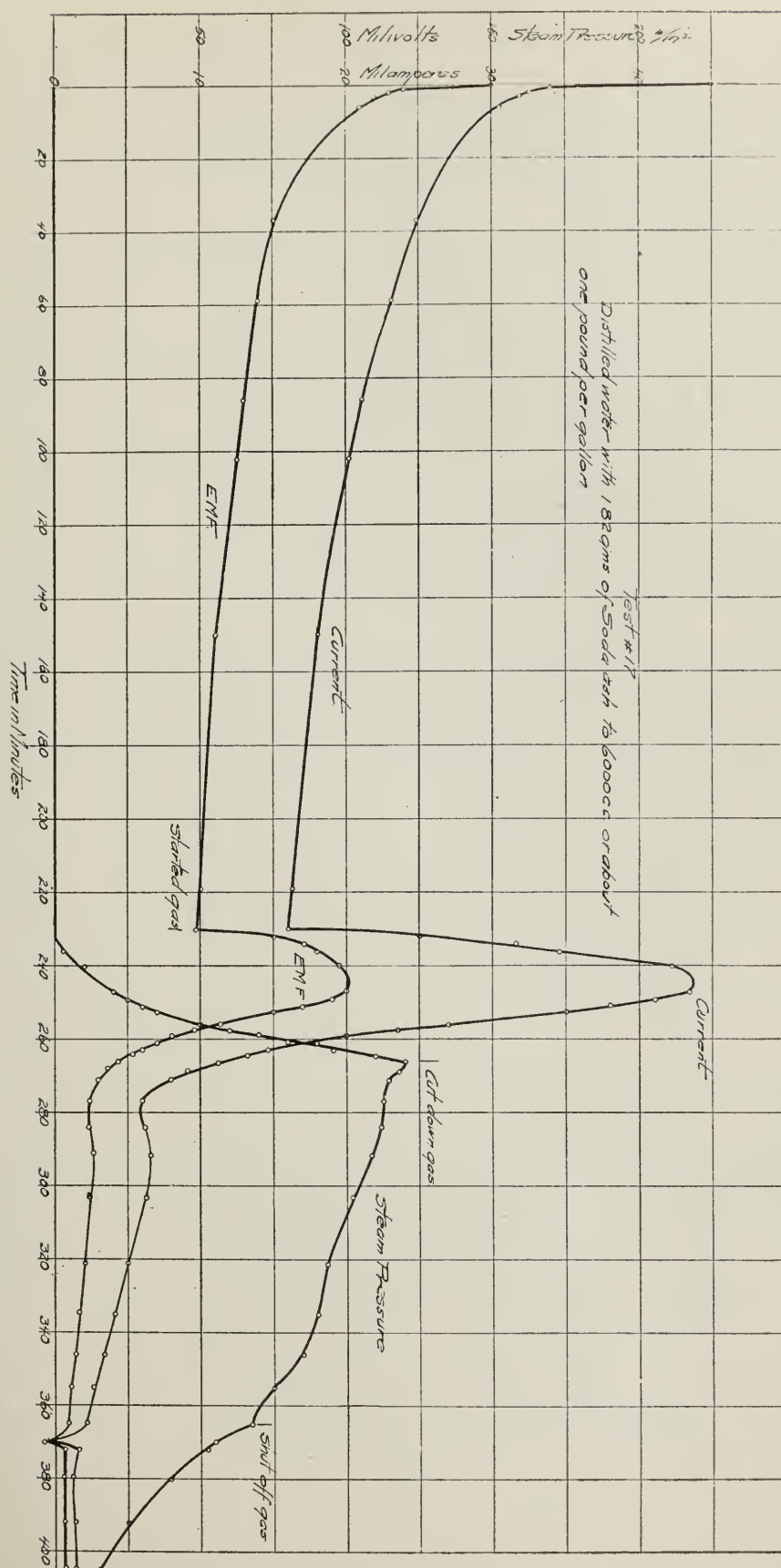


Test 15. Showing Effect of an Oxidizing Agent in the Electrolyte on Current and on Electro-motive Force.

June, 1909

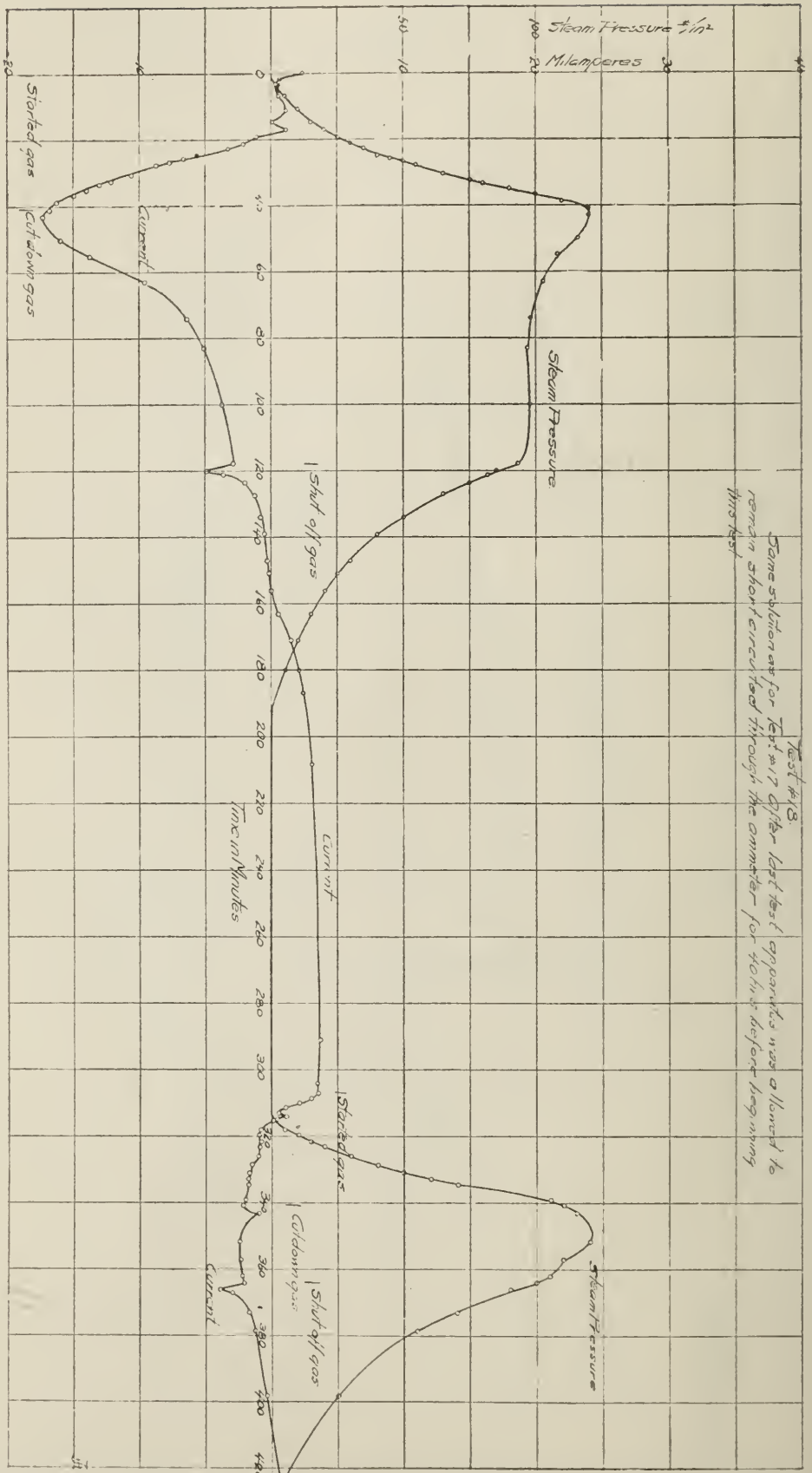


Test 16. Repetition of No. 15, with Rest Interval, Cooling off Apparatus.



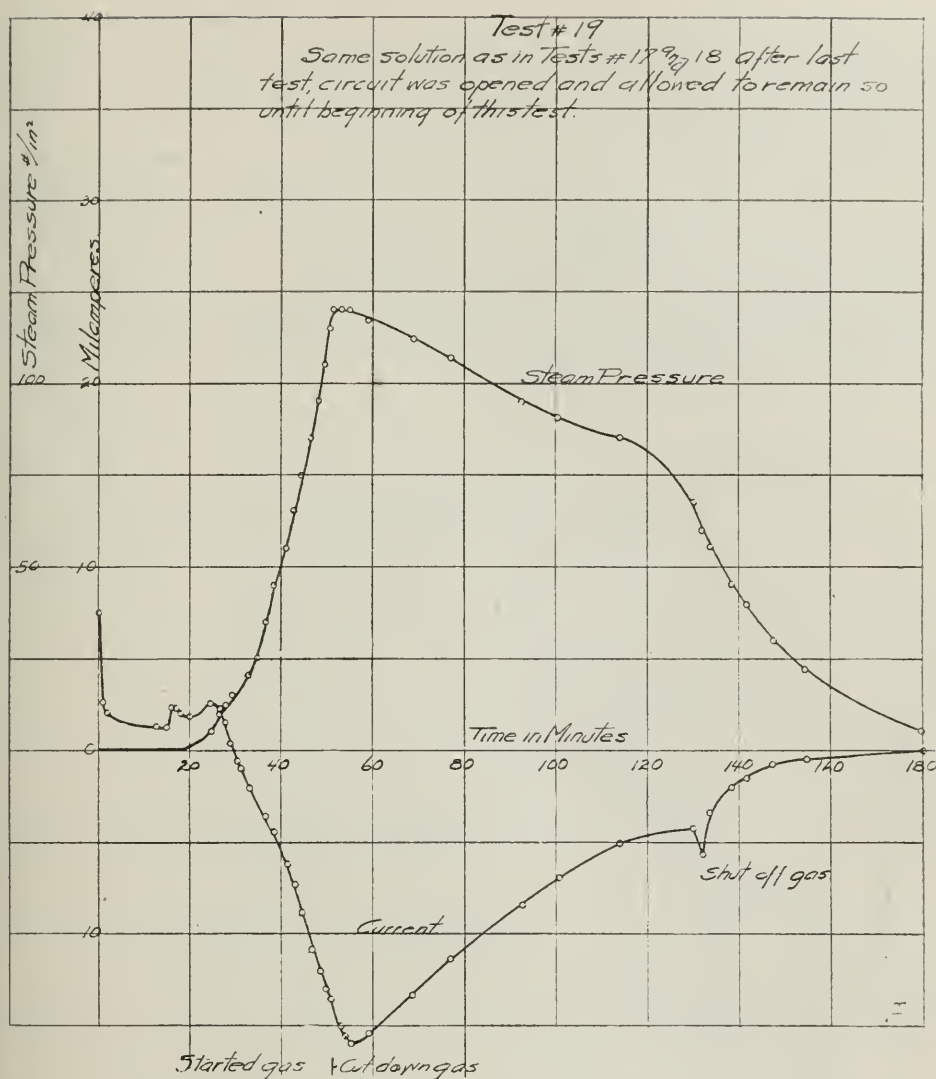
Test 17. Water made Alkaline, with Soda Ash, showing Increase of Current and Electro-motive Force.

June, 1909



Test #18.
Same solution as for Test #17 after last test apparatus was allowed to remain short circuited through the ammeter for 40 hours before beginning this test.

Test 18. Repetition of No. 17, with Rest Interval, Cooling off Apparatus.



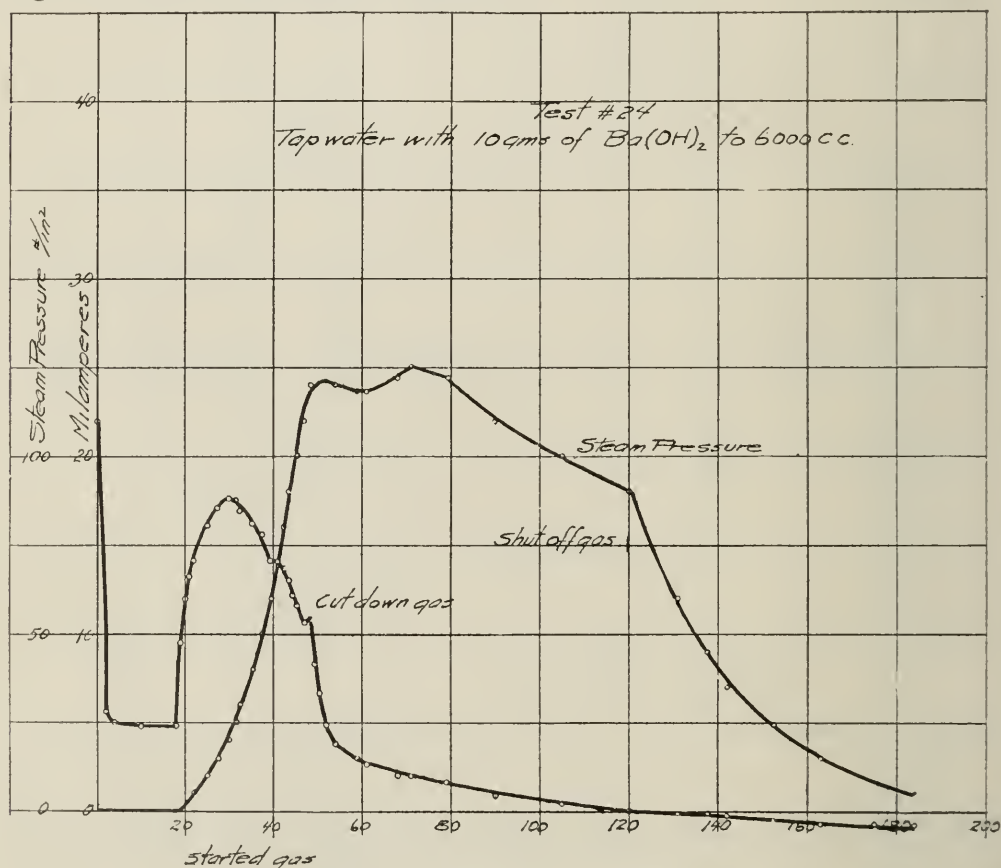
Test 19. Repetition of No. 17, and No. 18, with longer Interval for Cooling off.

Test No. 18, is a continuation of No. 17, after the apparatus had been allowed to remain short circuited 40 hours, and again applying the heat. This would correspond to the practical condition where a locomotive boiler containing this kind of feed water is allowed to cool off and is again brought up to normal steam pressure. The first half of the current curve in No. 18 shows that the inner tube now becomes the cathode, and such electrolytic corrosion as there may be, is on the outer shell of the boiler. On allowing the steam pressure to fall off by standing, but not waiting for it to become cold and then applying heat, the current is found to be materially less, and this may perhaps be attributed to the fact that in the second portion of the curve the temperature differences were less than in the first curve.

That this diminution is due to a diminution in temperature differences rather than to the consumption of some element in the so-

lution, is shown from test No. 19, where the apparatus and solution used in test No. 18 had been allowed to stand 17 hours, when the test was again repeated. In this case the negative current values are greatly increased.

Test No. 24, shows the influence of the introduction of barium hydrate on lake water; and test No. 25, is a repetition of the former test after the same solution in the apparatus had been allowed to remain for three hours, the circuit being opened. On repeating the heating operation the current decreased until it became negative, and the inner tube became the cathode, as was the case in a more marked degree with the soda ash solution.



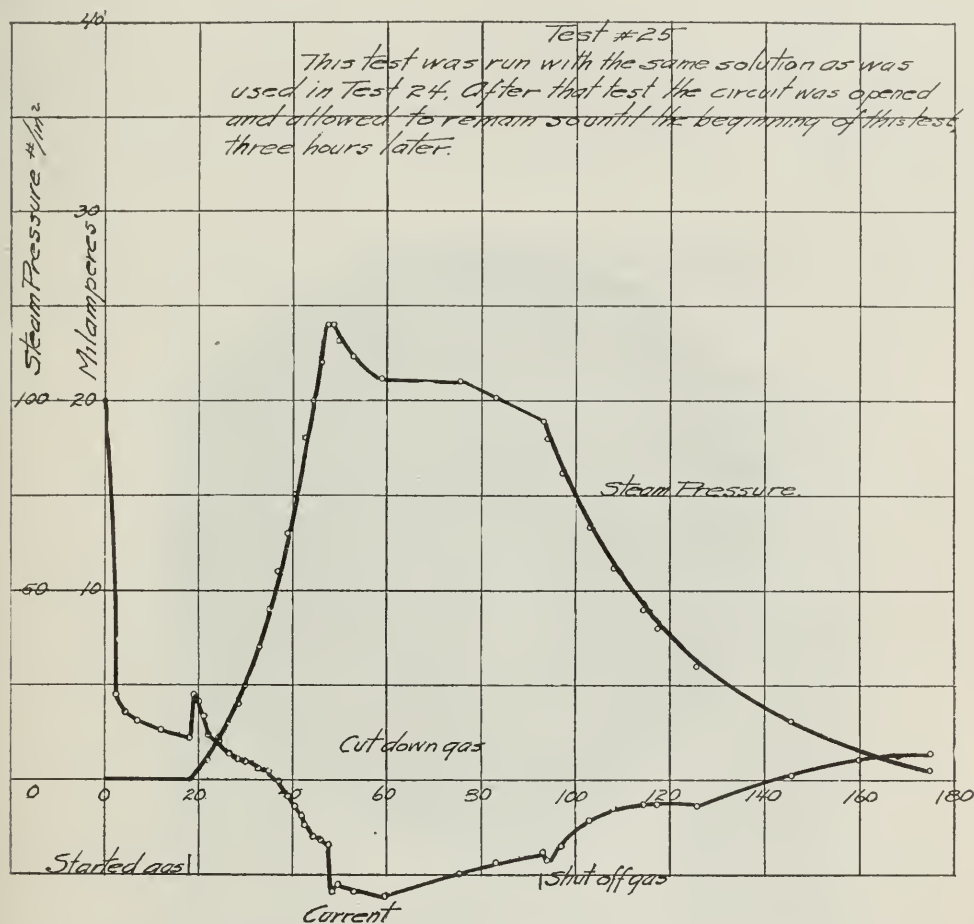
Test 24. Water made Alkaline, with Barium Hydrate.

Among the striking factors for which no explanation is offered, we may mention test No. 14, in which there is a momentary decrease in the current and electro-motive force just after the heat is applied, which is also shown in tests Nos. 15 and 16. Again on shutting off the gas there is a critical point in the curves in tests Nos. 12, 14, 15, 17, 18, 19, 21 and 25.

It is known that if the apparatus had not been cleaned out prior to each test, different relationships would have been shown, and the oxidation scale which forms on the inner tube is undoubtedly an important factor. In most cases this scale consisted of a firmly adherent black oxide, but in the case of the use of sodium carbonate,

where the inner tube was the cathode, the coating consisted of a loosely adherent brown oxide rust.

In most of the tests, the character of the corrosion on the inner tube was similar to the corrosion observed in locomotive boiler tubes. Incipient pitting was noted along the tube and especially in the lower portion. A marked pitting and grooving was also observed at the ends of the tubes.



Test 25. Repetition of No. 24, same Electrolyte, but Cooled off.

It is of course appreciated that absolute conclusions cannot be drawn from a small experimental apparatus such as has been described, as to what will take place in large boilers, but these experiments do demonstrate the possibility of marked electrolytic action. It is possible that we have a demonstration of the conclusion which is drawn from practice in boiler operation that repeated heating and cooling promotes corrosion, and that corrosion is greatly influenced by the quality of the water as regards purity and the "compositions" which are used for the prevention of scale.

We believe that in a small experimental apparatus of this sort, the qualitative and quantitative influence of various kinds of feed water can be studied, the results being procurable in a short time. If we may draw conclusions from some of the experimental runs

which we have made, one of them is to the effect that the presence of sodium carbonate in considerable quantity, will result in the heated tubes becoming the cathode, and consequently free from corrosion, the corrosion being on the other portions of the boiler; this we understand, agrees with actual experience in certain sections of the country where an excess of sodium carbonate is found in the boiler feed water employed.

If electrolytic action, maintained by differences in temperature, is responsible for a major or even a large portion of boiler corrosion, the remedy must naturally be found in means for preventing such electrolytic action, and it becomes therefore largely an electrical problem. Looking at the various possibilities from the electrical point of view, we have the following considerations. Electro-



Fig. 4. Strained Swedish Iron (300 diameters)

lytic action can be prevented if the solution be made a non-conductor, which of course is impossible from the practical point of view, since aside from cost, even distilled water is known to possess appreciable conductivity. Another method for interrupting the flow of current would be to prevent those parts of the metallic structure which are heated and therefore electro-positive, from making metallic contact with the other portions of the metallic structure. In other words,—if the tubes tend to corrode, the remedy would be to use an insulating packing where the tubes pass through the tube sheet. This, again, appears to be impractical. Attention may be given to reducing the electro-motive forces as far as possible, and improvement may be effected in this direction by a study of the influence of various compositions in the boiler water, and that this electro-motive force is subject to a certain amount of control is shown by the fact that we can

reverse the directions of the flow of current by varying the compositions of the water. It does not appear however, that any solution which might be discovered which would set up low electro-motive forces, would be in stable equilibrium.

We may note the more important suggestion, that the electro-motive forces be so distributed that the current flows in a direction such as to protect the more vital portions of the boiler,—that is, by making such portions of the boiler the cathode, the corrosion is prevented. This has been done by the use of zinc,—a metal which is highly electro-positive with respect to the iron and which, in contact with iron and the electrolyte, will make such iron the cathode. This protection is offered only at the expense of the consumption of the zinc, and many boiler users object to this remedy on account of the cost of the zinc, the difficulty of properly distributing it in the boiler and making metallic contact therewith, to the rapid disintegration of the zinc, and to the alleged harmful effects which zinc oxide has as a scale-forming material.

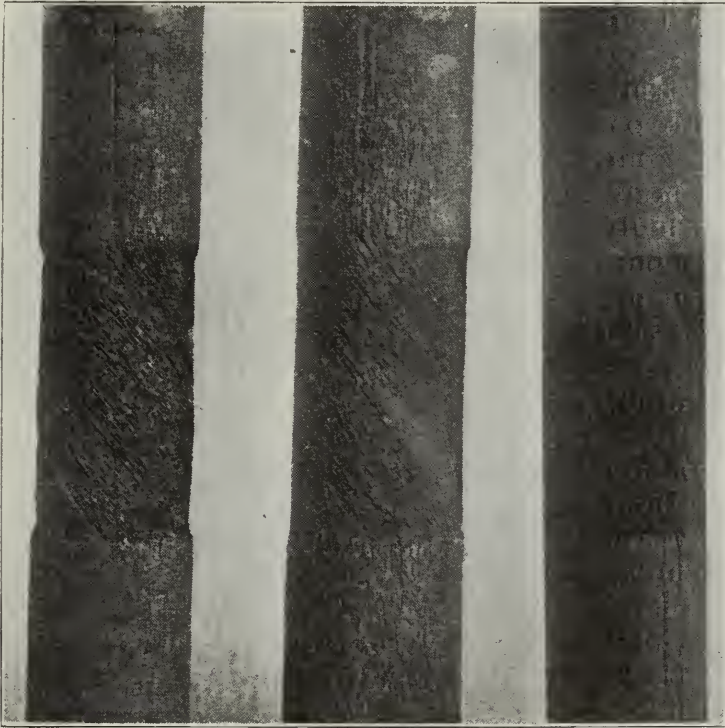


Fig. 5. Corroded Torsion Specimens

A proposition which is not entirely new, though I believe one which has not been given sufficient trial in practice, is to employ some other anode material which will not have the disadvantageous properties of zinc, and maintaining this as the anode, not by the energy which it possessed in itself, but from energy derived from an external force. For example, if an iron bar be made to take the place of one of the fire tubes in the locomotive boiler by passing it through the tube sheet by an insulating packing. This might be

made the anode, and all of the internal corrosion centered upon it by connecting it externally to the positive terminal of a source of electrical energy, such as a battery or small dynamo, the negative of which is connected to the boiler structure. If such anode could be properly placed, it is possible that protection could be afforded with the consumption of a small amount of electrical energy, in fact, an electro-motive force greater than one-half volt would probably not have to be employed and the current density could in all probability be kept at a very low figure. This is not given with the claim that it will cure boiler corrosion, but rather as an expedient which is worthy of further investigation.

In the experiments which have here been described, electro-motive forces of measurable magnitude have been found, but further experimental work will have to be performed before the source or sources of these electro-motive forces can be accurately located. In measuring the potential difference between two electrodes we have the summation of two potentials, that at the anode and that at the cathode, and the electro-motive forces which are referred to in this paper are such summations. A decrease in electro-motive force may be due to change in the contact potentials against the electrolyte of the metals themselves, or it may be due to polarization phenomena, caused by the liberation of hydrogen or some other material at the cathode, and by the liberation of oxygen or some similar material at

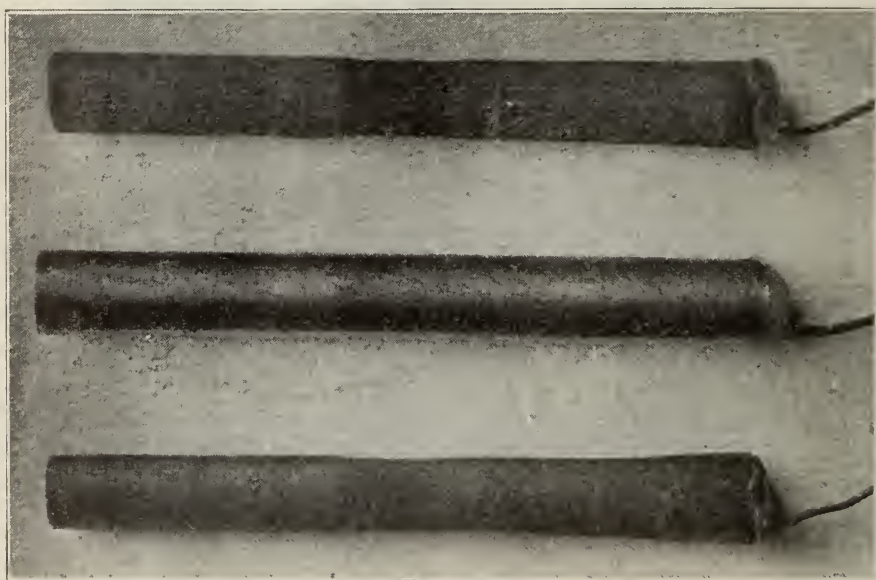


Fig. 6. Corroded Tension Specimens

the anode. These polarization phenomena, oppose electrolytic corrosion, and any factor which reduces the polarization will therefore promote corrosion. It is an idea commonly held that the presence of free oxygen in water is harmful in steam boilers in that it unites with the iron, resulting thereby in its corrosion, but Dr. W. H. Walker has pointed out with special emphasis, the important fact that free

oxygen promotes corrosion, not by uniting with the iron, but by uniting with the hydrogen liberated at the cathodic portions of the metallic structure. The oxygen uniting with the hydrogen, reduces the polarization at one place, and thereby promotes the corrosion of iron at another. Any other oxidizing agent in the electrolyte may be assumed to act in a similar manner. Likewise, a reducing agent dissolved or otherwise diffused throughout an electrolyte may have a depolarizing action at the anode.

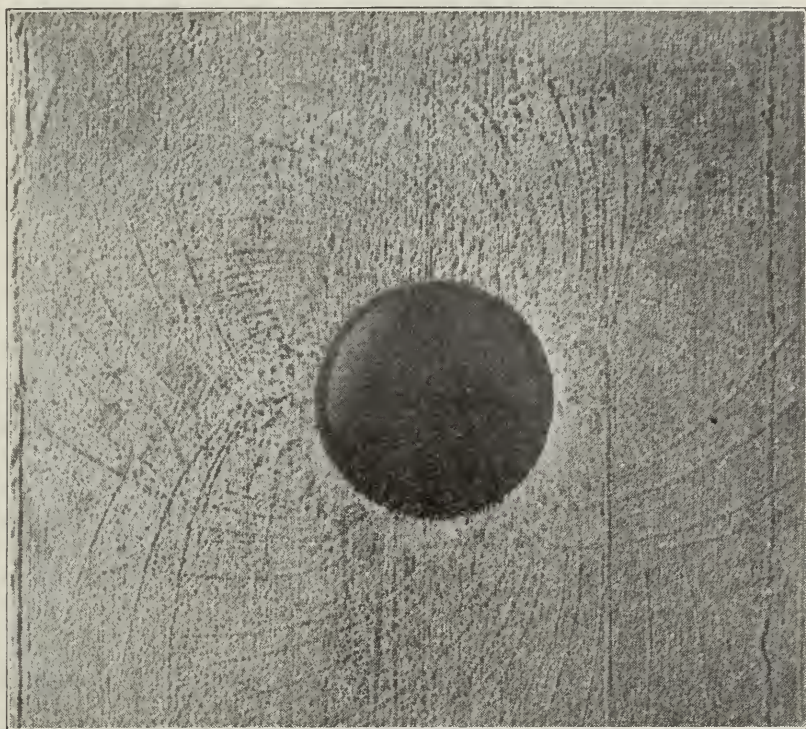


Fig. 7. Corroded Punched Plate

To obtain a more definite and clearer idea of the electrolytic phenomena herein described, it is desirable to study the changes in single potential at the separate electrodes; that is, the potential changes between the inner tube and the electrolyte should be noted as the temperature and other conditions are varied, and a similar study should be devoted to the outer tube, corresponding to the boiler shell. This can be done by employing a so-called normal, or constant, potential electrode.

That there are galvanic couples other than those produced by differences of temperature has been pointed out, and some illustrations are given here to show the influence of some of these factors.

It has long been known that iron and steel which has been strained beyond the elastic limit has its internal energy changed, which thereby sets up a different potential toward an electrolyte than would a normal metal. Quantitative effect of this straining is discussed in "The Corrosion of Iron from the Electrochemical Standpoint,"—Transactions of the American Electrochemical Society, April 30,



Fig. 8. Corroded Punchings

1908. A microscopic section of a pure Swedish iron is shown in Fig. A, which has been strained beyond the elastic limit. The groove lines running across the grains are the result of this straining, these grooves having been produced by the more rapid attack by a corroding agent than is produced on the remaining portions of the metal. That this uneven corrosion is not alone a microscopic phenomenon is shown by Figs. 5 and 6, which are photographs from samples of mild steel which had been strained either by tension or torsion, and then ground down to uniform cylindrical surface and subsequently corroded, either by making it an anode or by using a corrosive solution. That the strained portion has been the more electro-positive is shown by the more rapid removal of the iron from the strained portion than from the unstrained.

In boiler practice a drilled rivet hole is preferable to a punched one, in that the drilling does not weaken the surrounding metal. One of the causes of weakness of the surrounding metal by punching, are the strains set up which extend some distance from the rivet hole. Some steel plates $\frac{3}{4}$ in. thick were punched cold, the holes being 1 in. in diameter. These were subsequently corroded and the strain lines, which are shown in Fig. 7, were brought out. Punchings were likewise corroded, a non-uniform action being shown in Fig. 8.

Thus far it appears that comparatively little attention has been given to the microscope as a means for studying the corrosion of iron and steel. The histology of iron and steel has been shown to have great importance in the work done by metallographists during recent years. Their attention has been given, however, to studying the relationships between the metallographic structure and the physical properties. When we look at some of the photographs of microscopic sections of iron and steel we cannot help but be impressed with the possibility of the existence of numerous galvanic couples, the galvanic action resulting from which, will depend upon the electro-motive forces set up by the different metallographic constituents.

DISCUSSION.

Prof. P. B. Woodworth, M.W.S.E.: I am especially pleased with the simplicity and directness with which Prof. Burgess has attacked this very important problem. It seems peculiar that in the advancement of art and of genuine knowledge, we have spent centuries in discovering electrolytic action, and now that it has been discovered, we are using all our energies in trying to stop it.

Mr. W. L. Abbott, M.W.S.E.: I regret that I was not here in time to hear the first part of this paper, but the part I did hear was of great interest to me. I trust the paper will appear in print so that I can read it later on. It has always been a puzzle to me why boiler sheets and tubes should persist in corroding in the way they do; why a groove should be formed next to a seam where it would not be noticed without careful inspection; why a groove is cut around a rivet edge; and why sometimes it is the shell and sometimes it is the tube. Various schemes have been suggested from time to time to prevent corrosion, some of which have been mentioned this evening. The introduction of zinc or some other metal in the boiler shell is sometimes efficacious and sometimes it is not.

I remember at one time a scheme was proposed, and advocated very strongly under an alleged patent right, to put some mercury in the feed water pipe. I could not see that there would be any advantage in this and the people that proposed it did not give any reasons for its use. The mercury was not consumed but remained indefinitely in the pipe. It is possible that under some conditions the presence of that mercury might serve to prevent an electrolytic action which otherwise would have taken place.

In the use of some of the methods which have been proposed, of changing the polarity of different parts of the boiler by the use of outside sources of electro-motive force (outside current) I should think it might also have some effect upon the deposit of scale in the different parts of the boiler; instead of being deposited on the tubes, it might possibly be deposited on the shell, or vice versa. I did not notice that Prof. Burgess gave the electro-motive force which was developed in the shell (or couple) and I would be interested to hear something about this.

Prof. Burgess: I regret that the lantern slides did not come out more distinctly; they were intended to give that electro-motive force. The values were small. I think the maximum was not more than two or three tenths of a volt—usually just a few millivolts; the current on a two inch tube about eighteen inches long was somewhere in the neighborhood of eighteen or twenty milli-amperes. That current is enough to cause a perforation of the tube in a comparatively short time. If the auxiliary electrode has to carry enough current to overcome this small electro-motive force, it is evident the electro-motive force necessary for such current is rather small. The suggestion that those auxiliary electrodes might have an influence

on the scale question is of interest and experiments on this line have been carried out. I have attempted to repeat some of those experiments myself but fail to find that the current is effective in preventing scale deposition. The formation of scale is probably in no way associated with electrolytic action.

I had not heard of the use of mercury in boilers, but from a theoretical standpoint it appears that mercury would be a bad thing to get into the boilers and would promote rather than prevent corrosion.

Mr. Abbott: The use of the mercury was not, as I recall it, to prevent corrosion but to prevent the formation of scale.

I should like a little more information as to what kind of solutions make the tubes electro-positive and electro-negative, respectively. I understand from the diagrams and from the paper that locomotives using certain kinds of water are affected by corrosion of the tubes and with other kinds of water the shell is affected. Do your terms indicate that by changing the nature of the water you can change the corrosion from one to the other?

Prof. Burgess: That can be done. Our experiments in this line are incomplete, but with materials which we have employed we have found that soda ash (when sufficiently concentrated) and barium chloride, will make the shell corrode, while salt or magnesium chloride and any acid material, will reverse the action and make the tubes corrode. I understand however that the introduction of much soda ash, will cause foaming. I am, in fact, seeking information along this line rather than trying to give it.

The particular section of the country where the tubes were found to last a long time, was in Dakota where there is considerable alkali in the water, the foaming being remedied by using mineral oil. There appear to be a large number of engineers, who claim that oil is a bad thing to get into water on account of its promoting corrosion.

Mr. Abbott: The objection to oil in a boiler is that it forms a coating on the metal and prevents the water from cooling it. I have seen cases where a little cylinder oil will get into the feed water; it will adhere to the shell and the shell will soon be overheated and bag, but with the presence of soda ash there is a tendency to neutralize each other.

Mr. D. W. Roper, M.W.S.E.: I should like to inquire what is the minimum electro-motive force at which the corrosion will take place, if there is such a minimum point.

Prof. Burgess: I have been unable to find that there is such a point, when two iron electrodes are in contact with ordinary corroding solutions. It takes no definite value of electro-motive force to set up a corroding current. Although the statement is frequently made, that it takes an electro-motive force of 1.5 volts to produce electrolysis in iron where water is concerned, this claim cannot be verified by laboratory test.

Mr. C. Kemble Baldwin, M.W.S.E.: Have you noticed in connec-

tion with a bridge structure, whether corrosion is any greater on members that are strained excessively, than on members subject to their proper stress?

Prof. Burgess: There are cases where you will see more corrosion in one spot than in another, but whether such spot had been strained beyond the elastic limit is something which it is difficult to determine. I have never seen any cases of concentrated corrosion in bridge structures or on building-iron which can be definitely ascribed to straining action. There are cases where, in the laying of cable, the iron had been strained and at such points the corrosion has been very much more marked than in the normal iron. I do not think of any other marked instances of evidence of influence of strain in structures.

Mr. Abbott: There is one other point that I wish to speak about. I believe Prof. Burgess said that corrosive solutions were, in his experience, either acid or alkaline. He referred to the use of distilled water to prevent such corrosion. We find, as a matter of fact, that distilled water is more destructive to the pipes running to a boiler than anything else. In a system of piping which returns condensation from the pipes to the boiler, those pipes which carry the distilled water are the ones which give way first.

Prof. Burgess: That is a most interesting phenomenon. It is a matter, I believe, of quite general observation that distilled water is hard to handle, but just why it should be so, is difficult to explain. It might naturally be expected that pure water, comparatively without acids or chemical agents would be non-corrosive. One explanation commonly offered, is that there is more air in pure water than in ordinary water. I have noted in Kent's Handbook that distilled water cannot be handled in boilers without mixing with it a certain amount of "bad" water, after which it becomes "good."

Mr. Abbott: Distilled water, in returning to the boiler has no opportunity to absorb air. It is said that iron is comparatively easily soluble in very pure water, but I do not know that this has anything to do with electrolytic action.

Mr. J. L. Hecht, M.W.S.E.: Referring to the pure water which causes trouble in boilers and pipes, I have found that in hot water heating systems a combustible gas eventually forms, probably mostly hydrogen. On opening the radiator vent it is possible to burn that gas. It burns with a very blue flame for perhaps an inch or more from the vent, then red to a distance of 6 in. to 8 in.

Prof. Burgess: If it is combustible gas it is probably hydrogen.

Mr. R. F. Schuchardt, M.W.S.E.: I am greatly impressed with the value of the paper presented this evening. It is fortunate that our leading universities can and will permit men of the caliber of Prof. Burgess to devote their time and energy to problems of such tremendous commercial importance.

The present day is often called the "Age of Iron." The amount of this metal used in a single month at the present time is more, I be-

lieve, than was used in the entire century before 1850. It is this extensive use of iron which is making the progress of civilization at the present time more rapid than at any other time, in the history of man. I feel that we should congratulate ourselves that the results of this pioneer work have been presented to us, and I wish to move a vote of thanks to Prof. Burgess, on behalf of this Society, for his valuable and interesting paper.

PROTECTIVE COATINGS FOR STRUCTURAL MATERIAL

R. S. PERRY, PHILADELPHIA.

Presented April 21, 1909

Although it is the intention in this address to deal especially with the subject of protecting paints, and to adhere to this subject as closely as possible, it will be necessary to outline to you in a brief way some of the scientific investigations that have led up to the subject of rust inhibition, or the prevention of corrosion.

The United States government, two years ago, through the Department of Agriculture, started a series of tests to determine the causes of the rapid corrosion of the steel wire fences used by the farmers of the West to enclose the vast acreage of pastures and tillable lands. The complaints that the wire fences of today are found to corrode in less than one-fourth the time of the fences of twenty years ago have been found in many cases to be true, and the farmers and ranchers are justified in their demand for greater longevity for wire fencing.

Dr. Allerton S. Cushman who conducted the investigations found that the absence of certain impurities in the old time Swedish charcoal iron, the material largely used for wire fencing twenty years ago, was responsible for the rust resistance of this metal, whereas the steel of modern times contains impurities that cause its rapid disintegration. Modern methods of steel manufacture necessarily demand that the product be turned out in vast quantity and with rapidity, thus necessitating the use of materials such as manganese. Such methods cannot be overthrown at once, and we must look to the metallurgist for a solution of this problem. That such materials may assert a destructive action on the steel of which they form an integral part, there can be no doubt; the difference in potential of the area containing manganese in excess, to the potential of the area containing less manganese, causes the flow of an electrical current, with the consequent effect upon the solution of the metal. Marked segregation of the impurities is another factor of a destructive nature, and causes the formation of pit-holes which are of great danger.

That these points should be given more careful consideration was made plain, very recently, on an inspection trip to the tunnels of the Manhattan and Hudson Co. in Hoboken, New Jersey. Ten cars of one steel and ninety cars of another steel, that had been in service for six months, were brought into the roundhouse for examination. These cars had been built of two different grades of steel, but they were painted at the same time, with the same material and by the same workmen.

The conditions in the tunnel where these cars had been operated were most trying. Constant seepage caused drippings of an extremely corrosive nature to be deposited upon the cars' surfaces, and an analysis of the drip showed the presence of 15% of chloride salts which caused rapid acceleration of rust. The tunnel drip also had a

solvent action on the paint coat and in several spots the drip had completely removed the paint. The atmosphere in the tunnel was rich in carbon dioxide and high in moisture containing a considerable quantity of salt.

The large amount of rust formed on the edges of the cars could be accounted for by the abrasion of road-bed dust, hurled against these vulnerable parts by the enormous pressure, and consequent blast, of air that is exerted when the cars are running at full speed in the tubes. Another condition observed was the appearance of a white coating of salt upon the surface of the paint after the cars had been in operation but a short time.

Subjected to these trying conditions, some of the cars stood the test in a remarkable manner, while other cars, made of a different grade of steel, were in very bad condition.

The points of corrosion were indicated by the surface being covered with wart-like concretions which, under a high power hand glass, showed the presence of rust forcing through the paint coat and exposing the steel to direct contact with the air. This eczema of the iron, although general, seemed to be most marked in certain places, and this would lead to the conclusion that the impurities in the metal were segregated.

According to the electrolytic theory of corrosion, certain fundamental principles underlie the corrosion of iron.

They are, briefly, as follows:

That, when iron is in contact with water, there will be a transfer of electricity from the free hydrogen ions of the water to the iron ions of the iron, causing the solution and subsequent oxidation of the metal.

The presence of impurities having a difference in potential to that of the iron in which they are contained, and the uneven distribution of such impurities, increases the amount of electrical action.

We are indebted to Dr. William H. Walker for the most recent research on the function of oxygen in the corrosion of iron, who says,

"That the film of hydrogen deposited on the metallic iron at the beginning of the action is a non-conductor of electricity and prevents further passage of the current, and hence, further solution of the iron. Atmospheric oxygen removes the film of hydrogen by combining with it, thus 'depolarizing' the iron and allowing the solution of the iron to proceed. When once in solution in water, this dissolved iron is also oxidized by the atmospheric oxygen and precipitated as rust; but this oxidation is incidental to, rather than a necessary condition of, corrosion.

"That when iron is in contact with any surface on which this combination of the hydrogen, set free from the water, and oxygen, from the air, will take place more easily than on the iron itself, such as copper, bronze, mill-scale, etc., corrosion of the iron will be accelerated thereby."

Certain compounds are of such a nature as to excite electrical action, and, consequently, stimulate corrosion, while still other compounds are of such a nature as to inhibit or prevent corrosion.

To the class of compounds that inhibit corrosion belong bichromates of the alkaline earth metals, these salts being pre-eminent among such compounds. It has been found that salts of certain metals may be precipitated with the chrome salts to produce pigments which afford protection for the steel surfaces to which they are applied.

The results of a series of investigations into the rust preventive nature of these compounds demonstrated that it was not safe to state that the chromates, as a class, were rust-inhibitives. Quite the reverse is true of many of these products, and their composition, method of preparation, and impurities are factors which influence, to a marked degree, their value as protective compounds. Aside from those chromates which prevent corrosion, we have those which act in an inert manner, also those in which any inhibitive value is overbalanced by the effect of impurities, showing a strong stimulating action in the rusting of metal. But a simple test will show in which class the chromates come.

Turning, therefore, to the conservation of structural iron and steel and to its rust inhibition through particular coatings, we have the problem of choosing the proper materials for manufacturing a paint which will both exclude the agencies of rusting, and which, when moisture and gases do penetrate the coating, will inhibit the iron from rusting; and we also have the problem of giving to the chemist, engineer and architect some simple method of determining whether any given paint is, in at least a rough measure, harmful, safe or beneficial.

Some pigments largely used in the paint industry, and of value in a paint for protecting lumber, are unjustifiable in a paint for the protection of steel and iron. For example, sulphate of calcium, which, even if fully hydrated, has been shown to have a direct stimulative action upon steel. This is due to the fact that calcium sulphate, even if fully hydrated, is somewhat soluble in water, and when the water penetrates the coating of paint it carries this calcium sulphate into solution. Owing to the fact that calcium sulphate, in solution, has a high co-efficient of dissociation (or, in other words, has a tendency, in solution, to break up from its chemical form and identity), we get the reaction of the liberated sulphuric acid ions upon iron and steel, causing corrosion.

The highest types of paint product for the protection of iron and steel, therefore, avoids the use of such pigments as calcium sulphate.

Great caution must be used in selecting iron oxides for the protection of iron and steel, as they often carry traces of sulphates, etc., as impurities.

Venetian red, which is a favorite pigment, and which is of value for protecting lumber, is made by calcining green vitriol or sulphate of iron (commonly called copperas) in the ferrous form, in the pres-

ence of quick lime. The resulting mass from the furnace consists of artificial oxide of iron and sulphate of calcium, produced by the metathesis of the above reacting compounds.

Unfortunately, the reaction is never complete, and there is a tendency towards the formation of free sulphuric acid.

As a result, we have all the bad effects with Venetian red that we find in the use of calcium sulphate, and also the extra chance of corrosion due to free and aggressive sulphuric acid present.

It is true that there are some *artificial* oxides of iron which can with safety be used, as for instance, artificial black magnetic oxide produced by chemical precipitation, but, as a general proposition, the *natural* iron oxides should be used, unless it is absolutely certain that the artificial oxide has been proven safe.

Ochres are not meant to be included in the safe class in the above statements, for the reason that ochre is an extremely impure oxide of iron.

Recent investigations into the nature of pigments have revealed the fact that they may be divided into three groups and termed "Rust-Inhibitives," "Inerts," or "Rust-Stimulators." The nature of the pigment itself, or the nature of the impurities contained within the pigment, are factors deciding the position of the pigment in one of the three groups or types above mentioned. It may be expected that the use of rust-inhibitive pigments in paints designed for the protection of steel surfaces will give to such a paint very valuable properties. Further consideration of the subject will aid us in selecting the proper pigments for such a purpose.

In order to ascertain the rust-inhibitive value of all pigments, the Scientific Section was commissioned by the Bureau of Promotion and Development of the Paint Manufacturers' Association to erect a fence, having several hundred steel plates, upon which to try out the value of the different pigments when contained in an oil medium.

The American Society for Testing Materials was informed of the work proposed by the Scientific Section, and Committees E and U of that society decided to cooperate in inspecting and supervising the tests, proper specifications to be drawn up by the committees. The members of these committees and the Scientific Section conducted laboratory tests that served as a check upon the previous investigations and gave information upon which to base the main field tests. The plates used for the tests were rolled from three kinds of metal—ordinary open-hearth structural steel, ordinary Bessemer low carbon steel, and pure ingot iron. In this way was secured data relating to the resistance to corrosion of certain metals when tested out simultaneously with others. The steel plates were painted in two ways, part of them being scratch-brushed in the ordinary way before painting, thus following out the usual mode of painting structural steel, and part of the plates being pickled in sulphuric acid, in order to completely remove the scale, and the plates were subsequently washed with lime so that all traces of the acid were neutralized.

The test was conducted in a thoroughly systematic and practical

manner, following out the methods employed during the tests already made at Atlantic City and Pittsburg. The Master Painters' Association co-operated in the work and gave us the benefit of their practical experience in this line. Inspectors and painters, representing the committees and sections, were upon the ground throughout the period during which these tests were made.

It has been proven that corrosion generally takes place under normal conditions in an uneven manner, and pitting is evident at certain weak spots on nearly every grade of steel or iron, in a lesser or greater degree. From these spots the corrosion proceeds and develops upon the surrounding area. The corrosion at the start, where the pitting begins, is so extreme in some cases that holes are formed, of considerable depth, before the surrounding surface is attacked to any marked extent. The causes of this pitting have been fully explained by the electrolytic theory. This theory overthrows the former theories which were held, regarding corrosion. The carbonic acid theory, for instance, held by Calvert, supposed that carbonic acid attacked the iron, converting it into carbonate, and the carbonate being oxydized to hydrate or ordinary rust by the oxygen of the air, the carbonic acid regenerated and acting again on an unattacked part of the metal. According to the peroxide theory, the iron, oxygen and water were supposed to react to form ferric oxide, and to regenerate hydrogen peroxide which would attack a new quantity of iron. That the electrolytic theory is the most tenable has been demonstrated in many ways, but one of the most beautiful demonstrations may be carried out in a very simple manner.

A five per cent. solution of gelatine in hot water is made, and, after careful neutralization, a few drops of phenolphthalein and ferrocyanide of potassium are added. A thin layer of this solution is poured upon the bottom of a glass dish, and when stiffened up by cooling, a clean strip of metal is placed thereon. A further quantity of the gelatine solution is poured upon the metal and allowed to solidify. The gelatine in this case is used to retard diffusion of the colorations which form. As stated before, when a strip of steel is placed in water, there are developed hydroxyl (OH) ions at the negative pole, and these are shown by a pink coloration formed with the phenolphthalein, whereas at the positive pole of the iron plate the development of hydrogen ions takes place, and solution of the iron proceeds. This solution forms, with potassium ferrocyanide, a blue coloration which to the paint chemist is known as Prussian blue.

It is a well known fact that zinc protects the iron from corrosion when in contact, the zinc going into solution, being electro-negative to iron, thus protecting the iron from being acted upon. It has been found that the zinc will protect the iron only to a certain extent, unless an electrolyte is contained within the water, this being due to the fact that pure water offers too great a resistance for the current to flow.

It has been shown by our investigations that certain pigments have the property of preventing galvanic action, and their use is

highly desirable in a paint coating. Other pigments have been found to exhibit a strong tendency to excite galvanic action because they possess the property of being good conductors of electricity. Such pigments should never be used next to steel.

The Scientific Section of the Paint Manufacturers' Association have made a very careful and systematic study of this vital question and are at present pursuing the work started, making tests of extreme value and recording their observations for future generalization. Such work can only be productive of the most valuable results and will ultimately result in the restriction to certain materials for use in painting iron and steel and the adoption of these materials in specifications for such work. The qualification of each and every raw product will be determined, and its legitimacy for existence in a paint will be closely questioned before giving it final approval.

It is not the intention to make any derogatory reference to certain products which are under suspicion or to attempt to tear down the business that has been built upon these products, but before we can give our candid endorsement to any raw product for use in a paint to be applied direct to iron or steel, that product must possess certain fundamental requisites which we have already outlined. The distinction between an inhibitive and a stimulative pigment may be easily determined, and it is essential to the preservation of the steel upon which such pigments are to be used, that the inhibitive principles should predominate.

That there is a marked difference in paints as well as in steel has been proven beyond the shadow of a doubt, and evidence is collected every day confirmatory to this statement. One of our foremost metallurgists recently returned from a visit to the Isthmus of Panama, and, while there, he inspected some of the old steam engines used by the French government, in their futile attempt to join the Atlantic and the Pacific. These engines had lain in the morass and jungle for many years, subjected alternately to the torrid heat of day and the excessive humidity of night; rare conditions for active corrosion being always present. Some of the engines were nothing more or less than a flimsy network of holes, and the material had completely gone to waste (of the open-work variety), resembling the latest thing in summer hosiery. Other of the engines had been protected with certain paint coatings that had preserved the steel intact, and the American engineers were able to pull these engines out of the morass and by substituting a few accessories, to use them again. The nature of these coatings which have withstood the test of years are at present being investigated by the Scientific Section to determine the pigments used therein.

Another engineer recently returned from Colon reports that the iron posts surrounding the consul's home and from which were suspended a line of linked chain, showed active corrosion on the south-east side in every case, while the back of the posts were slightly, if at all, affected. These posts back of the consulate were unaffected

in any place because of the protection from the southeast winds afforded by the house. The winds blowing in, laden with salty humidity, had naturally exerted their corrosive effect on the surface not thus protected.

A recent examination of the steel test fences erected by the Scientific Section, at Atlantic City, was confirmatory of the above. The inspection was made early one morning, after a rainy night. The weather had cleared up and the brisk wind which had continued throughout the storm was blowing from the same direction and rapidly drying the moisture on the steel plates. The object of the inspection was primarily to determine the moisture penetration and water shedding properties of each pigment and paint. A better day or time for such a test could not have been chosen.

As has been described before, the fences are three in number, made of three classes of steel and each presenting toward the sea a series of 100 plates with as many upon the reverse side. It was apparent at once that the rain had impacted only against the steel plates facing the ocean or shore side, and that our inspection would have to be made from the plates on the reverse side of the fence.

The panels facing the ocean and exposed to the action of the storm exhibited a variance of results. Some had been painted with pigments having a greasy nature, and being natural water-shedders were apparently dry, while others, painted with less greasy pigments, held on their surface a large number of rain drops. By wiping off these rain drops, the following differences were noted:

(1) That in some cases a place resembling a water blister was left, showing just where the drops had remained on the surface, and showing that they were acting upon the paint coat.

(2) In other cases, when the drops of water had been wiped off, the surface was in the same condition as the balance of the plate, and the rain had no apparent effect upon the paint coat. On some panels, the penetration of moisture through the paint coat left a blotchy surface. This appearance being present on many panels, a record of impenetrability was obtained.

Very few corporations, whether manufacturing paints or buying paints, and very few engineers or architects have the facilities or the time to make exhaustive laboratory research when choice is to be made of a protective coating for their use.

What the practical man—either the paint manufacturer, the architect, or engineer—requires, is to have some practical result, easily obtainable, which will give him, in a definite and visible manner, a criterion and measure of the value of the new discovery, and of the refined laboratory work.

This accelerated field test consists in subjecting strips of any particular kind of steel that may be chosen to an atmosphere of maximum humidity, the steel being in intimate contact with the materials concerning which results are desired.

The apparatus is extremely simple, and the test can be started at thirty minutes notice by any manufacturer, architect or engineer, at

his office desk, and can yield him visible results in two days thereafter.

The idea was original with Dr. Cushman, and permission was requested from him to work it up in some practical way for the manufacturers of the raw materials and of paints, and for the consumers who have the work of protecting structural steel.

The chemist, engineer or architect who wishes to conduct this test on actual paint products instead of the materials used in the manufacture of paint products, may use a \$7.50 centrifuge apparatus made by Bausch & Lomb, in other words, a small laboratory centrifugal machine holding test tubes.

Number the test tubes for reference purposes and place in each test tube a small sample of the paint to be tested, together with a large quantity of benzine. It is of extreme importance to add the benzine in considerable quantity and previous to inserting the tubes in the centrifugal machine.

Actuate the apparatus and most of the vehicle will be thrown away from the pigment and the pigment will settle toward the bottom of the tube.

Decant or pour off the oil, add more benzine, thoroughly shake and pour off the liquid. Do this two or three times until the oil has entirely left the paint and nothing remains but the dry clean pigments.

Then take the pigments and proceed with the whole test as described below for the testing of dry pigments.

The materials required are as follows:

An ordinary deep cigar box.

2 or 3 sheets druggists' thick filter paper.

1 dozen thumb tacks.

1 dozen safety razor blades (unless some special steel is to be tested).

½ dozen small butter dishes or saucers.

Each of the dry materials to be tested.

A clean pencil for stirring.

A pocket knife.

A glass of water.

An old towel or rag for cleansing hands, pencil, etc.

A piece of emery cloth.

A tooth brush.

2 or 3 test tubes.

Line all six interior surfaces of the cigar box with the filtering paper, using the thumb tacks for the purpose. Thoroughly wet the lining of the cigar box with water and stand it on one edge so that when it is ready for use it will be free from drip.

Place upon a piece of filter paper, large enough to cover the hand, some of the material under examination, add a few drops of water and rub up with the finger into a rough soft paste, this being easily accomplished with nearly all pigments, and bringing into a paste many pigments which are otherwise extremely difficult to incorporate

with water. Be particular to cut the surface of the razor blade to the raw steel with "00" emery paper, to insure the removal of any lacquer or surface treatment of the blade. It is necessary to handle the razor blades by the edges so as not to get any finger marks upon the surface. Now place a clean razor blade upon the plate, fold over the filter paper on each side of the razor blade in such a manner as to completely cover it with paste-coated filter paper, and place blade, paste and paper upon a butter dish within the cigar box.

Treat each sample of material under test in the same manner.

A word of caution is necessary regarding the testing of the inhibitors such as the chrome soaps, that are soluble in linseed oil.

These are not pigments, but soluble in the oil and vehicle constituents, and therefore must not be applied in a water paste, but in a film, through the agency of benzol.

In the case of these materials, soluble in linseed oil, such as resins and linoleates, these are to be dissolved to a heavy solution in benzol, and a coating poured upon the razor blade. The evaporation of the benzol leaves upon the surface of the blade a thin film of the material to be tested, and, because of the fluidity of the benzol and consequent thinness of the film, a second coating is advisable. The coated blade is then to be placed in a butter dish within the box along with the other materials with which it is to be compared. Care should be taken that the plate is completely coated as there is a tendency for the liquid to segregate on the steel.

If a strip of steel in every case be treated with potassium bichromate in such a test, a convenient standard of minimum corrosion will be afforded, for purposes of comparison.

If so desired, in the foregoing test the operator may increase the quickness with which the test may be performed, by adding to a little bicarbonate of soda (baking soda) on a butter dish, a little sulphuric acid. An evolution of carbonic acid gas will ensue and as this gas rapidly stimulates corrosion, its presence will render the test still more positive.

A considerable degree of refinement and a fair index of result can be obtained from this apparatus if the strips are first carefully weighed in a laboratory balance, and then reweighed after the steel is scrubbed with a tooth or nail brush to remove any rust formed, in which case the loss in weight of the steel is the measure of the rust formed and the degree to which the pigment has stimulated rust.

It is evident to any man who will compare the conditions in this test with the field conditions, that practically all of the important factors which contribute to the corrosion of steel are present in this test in such a way that they will indicate in a short time the results which would be obtained from the steel painted with a paint coating produced from these materials and over a considerable length of time.

After the proper selection of pigments has been made, the question of vehicle must be carefully considered. The addition of high grade fossil resins, carefully compounded with a carefully treated oil,

adds greatly to the power of a paint to resist penetration by gases and moisture, producing a better excluding paint and at the same time adding to the appearance. The glossy surface which a paint made along these lines possesses renders the paint a better repellant or resister of moisture. The quality and percentage of gum used influences to a great extent the wearing properties of this kind of paint.

During the transportation of machinery and structural steel from the factory to the field and the workshop, there is met a state of conditions that causes rapid corrosion. Moisture and gases attack the metal and assert their destructive action. In the past these results have been partially overcome by swabbing the metal with crude oil, in some cases, and, again, by giving the metal a dip in hot linseed or other drying oils or by applying tar and cheap paints as shop coats. The crude oil leaves upon the surface of the metal, even after wiping, a quantity of non-drying mineral oil which interferes with the drying of the paint coat which is afterward applied at the time of the assembling of the metal. It also prevents the paint coat from properly adhering to the steel surface, and this coat of crude non-drying oil, which still exists between the metal and the paint coat, is a source of never-ending trouble, causing peeling and shriveling. This crude oil treatment, therefore, should be avoided whenever it is intended that the steel is to be subsequently painted with oil paints.

Where linseed oil instead of crude oil is used, a film of the oil is left upon the metal and rapidly oxidizes to a coat of linoxyn. This coat will protect the metal for a certain period of time, but is extremely porous and ultimately admits moisture. If, within this coating of linseed oil, there had been contained a proportion of pigment, or if the linseed oil had been developed by gums into a varnish or lacquer, then the excluding properties of the linseed oil would have been increased, and, if the formula were inhibitive in nature, the steel would be better protected from corrosion, and the application of future coats of paint, after assembling the steel, would have been practical and facilitated.

It is sometimes desired to give to steel a thin adherent protective coating that is transparent and will allow of the inspection of the steel by the engineer, who desires to observe whether the metal is absolutely clean and free from rust before proceeding with the painting thereof. In a case like this, there is required a coating of oil containing materials which will not interfere with the transparency of the oil coat and which, at the same time, are thoroughly inhibitive in nature. Such a compound may be prepared by the use of inhibitive chromium compounds soluble in linseed oil, such as chromium resinate or chromium linoleate. By the use of these materials within an oil coat, thorough inhibition is obtained, and, at the same time, there is added the excluding properties which these compounds afford. A thoroughly inhibitive and transparent coating is thus formed and is most practical of use. A paint coat applied to steel protected by

this inhibitive oil coat amalgamates with this oil coat and becomes an integral part thereof, rendering at the same time, the oil paint thoroughly inhibitive and causing close adherence to the metal surface.

DISCUSSION.

Mr. George M. Davidson, M.W.S.E.: I would ask Mr. Perry what he thinks of lamp black as a protective coating?

Mr. Perry: Thus far we have found lamp black in the same class as graphite, carbon black, etc. You will remember, gentlemen, that I said those materials are the most wonderful excluders we have,—the most noted in their characteristics of exclusion, and give high excluding values to a paint. Unfortunately, however, when the paint coatings begin to give way the evil starts. There are some blacks which are safe—blacks made from vegetable and animal charcoal, containing small percentages of alkali, which are slightly inhibitive—and they can be used as substitutes for graphite, carbon black, etc. Please understand, though, that I am not attacking lamp black, graphite, and carbon black; I am simply trying to state exact facts from a technical standpoint, and any of you can determine these facts for yourselves.

Mr. Davidson: I have an example in my office, showing the durability of lamp black on iron, in the way of a piece of 3 in. suction pipe taken from a well. When that piece of pipe was sent to the point where the well had been dug, it was marked with the initials of the railway company, in lamp black. That pipe was eaten through by corrosion in a great many places, and has the appearance of having had a good case of smallpox, except where the initials of the railway company were put on. In that case it would seem that lamp black offered a protection to the material from which the pipe was made.

Mr. Perry: I am very glad that Mr. Davidson brought up this illustration. I could not have asked for a better one, to show exactly what happens when those blacks are used with iron and steel. I am going to use a homely example, for instance, a wet battery such as is used in operating telegraph instruments. It is composed of carbon, zinc, and solution; by wire connection you get an electric current. The zinc dissolves in proportion to the electric current, while the carbon remains unaltered for any length of time it is left there. If iron is substituted for that zinc you will get an electric current and the iron will dissolve in that small glass battery in proportion to the electric current, but the carbon will remain undissolved for any length of time. When the lettering was put on the pipe which Mr. Davidson has referred to, and the pipe was plunged into the water, it made a very nice battery. The iron dissolved and the carbon remained intact—a beautiful proof of the fact that carbon is a poison to iron.

Mr. E. N. Layfield, M.W.S.E.: The use of the test in determining the two values of the pigment, was not very clear to me. One of the values of the pigment is its inhibitive value, and the other is its excluding value in a paint. This test, as I understand it, showed only

the inhibitive value and not the excluding value. We will suppose we had a pigment comparatively low in inhibitiveness and very high in exclusion; what would be the result?

Mr. Perry: You have put your finger right on the matter. The first thing to be done is to set aside all those compounds which are poor excluders and forget them; then from among those which are good excluders choose the ones which are good inhibitives or which are inert, but not those which are rust-stimulatives. I stand corrected, that to-night I did not take up the question of the function of the pigments as excluders, because it would have made my paper too long, but I have handled that phase of the question fully in other lectures. It is largely a "rule of thumb" matter and the result of years of experience of paint manufacturers. Fortunately some of the best excluders are rust resisters.

Mr. O. P. Chamberlain, M.W.S.E.: I presume, Mr. Perry, the idea is to take out the pigments which you know are excluders, first, and then make a test of them.

Mr. Perry: Yes, that is the idea.

Mr. Charles K. Mohler, M.W.S.E.: While I understand that Mr. Perry has studied the question almost entirely from the standpoint of paint protectives, I would like to know if he has made any study at all of the action of concrete and mortar in excluding rust? This has become a very important factor in building construction, and I would like to know whether it is a protector and can it be relied on.

Mr. H. A. Gardner: The protective properties that concrete or cement sometimes afford structural steel is due to the percentage of lime they contain, the lime acting as an alkali prevents the formation of hydrogen ions which is one of the primary causes of corrosion. Nevertheless when steel or iron beams are embedded in concrete and they are connected by metal, there will sometimes be a flow of electric current unless the metal is thoroughly insulated. Consequent corrosion generally forms at the beam which is the anode and the corrosion proceeds, in some cases, to a great extent. The molecular increase which takes place under these conditions is very apt to cause a splitting of the concrete. It is thus evident that even in the presence of a large percentage of lime, cement is not a protective against electrolytic corrosion unless there is absolute insulation of the steel and iron.

Mr. F. H. Bainbridge, M.W.S.E.: I would ask if there is any good reason why the rail which is in use is generally free from rust, while the rail which is out of use rusts rapidly.

Mr. Perry: I will try to answer that question in part. The effect is partly deceptive. The rail in use is being constantly hammered, and if you will examine the right-of-way you will find discoloration on either side of the rail. In other words, the freedom from rust is deceptive in its appearance, as the rust is being constantly removed by the passing trains. That is part of the answer and a practical one. There is another question, however, which is rather involved and

which is being followed out,—a theory that the actual use of the metal causes depolarization. That is a very large question and a very technical one.

Mr. Bainbridge: I know of some iron tanks in water service which have been in constant use for twenty years; they were not painted inside and there is almost no evidence of corrosion in those tanks at all. If the tanks had been left for six months without use, without question they would have gone to pieces very rapidly.

Mr. Gardner: Nearly the same thing happens in water carriers. The water flowing through the pipes does not allow foreign matter to be deposited, whereas if the water is allowed to stand in the pipes, impurities and foreign matter collect and act as electrolytes, stimulating the action of any electrical currents which may be present. As long as the water is kept in rapid motion, there is little opportunity for rusting to take place, even when the water contains a very small percentage of acid. I would like to ask Mr. Bainbridge whether the water in the tanks he mentioned was of alkaline reaction?

Mr. Bainbridge: The tanks I referred to were in use on the Santa Fe road, out at Belmont, Arizona. The water was good drinking and washing water.

Mr. J. H. Warder, M.W.S.E.: Some years ago, when at one of the eastern bridge shops, they had a contract that required the completed bridge members to receive a coating of some asphaltic mixture, put on hot. A wooden tank was built, long enough and large enough to take in the large, complete member, as an end post. Steam pipes in the bottom of the tank served to heat up the asphaltic mixture, and the bridge members were immersed therein until the metal was thoroughly heated through and then lifted out and the surplus coating drained off. This operation must have added considerably to the cost of the bridge, and from what has been said about bituminous paints, was this extra work a waste of money?

Mr. Perry: The asphalts are practically a poison to the iron and steel, and if careful observation had been made in those cases after two years, the corrosion would have been found under that coating. I will ask Mr. Gardner to describe certain tests where bitumen was used.

Mr. Gardner: The bitumen we used on plates was coated with red lead. After the plates had been on the fence for about a month, an observation was made and in nearly every case a fine checker-board work was to be found. The unequal expansion of the red lead and of the bitumen caused those cracks to be formed.

Mr. W. H. Finley, M.W.S.E.: A number of years ago some water pipes were being placed in the city of Minneapolis, and these were immersed in hot asphalt until the metal was brought to the same temperature as the asphalt. An examination some years afterward showed the pipes to be in an excellent state of preservation. Of course, that is very different from just painting.

Mr. Perry: I agree entirely. I will give my own practical ex-

perience as an engineer, and say that those tars, asphalts, and bitumens have been found dangerous unless lime was added and boiled with the tar or bituminous material. I think in England lime is always used.

Mr. Finley: In connection with railroad structures, probably one of the worst things to be dealt with in the matter of corrosion is the drip of brine on structures. I have seen the brine go through all sorts of protectives, the result being rapid rusting. I do not know yet of anything that has given good results in this matter.

Mr. Perry: Mr. Gardner was present at some inspections along the line of this brine question, and he will tell you something about that.

Mr. Gardner: Regarding the action of brine on steel and iron, I might state that the corrosion is very rapid. In sea water there is a large percentage of chlorides of sodium and magnesium, both salts which are easily dissociated into their component parts, the chlorine ions attacking the iron with great rapidity and accelerating corrosion to a great extent. These salts also act as electrolytes and increase the conductivity of water, promoting galvanic action.

Mr. Perry: I might add that the scientific paint coating to protect steel is first impenetrable, and second, when with age it becomes penetrable, it will be inhibitive, and you must understand that it is not a perfect paint coating, but simply the best we have been able to produce as yet. The new science is very young—only about six months old—and less than two years old in its conception.

Mr. Finley: Is the paint that is made of the gum or resin flexible enough to take care of the expansion and contraction of the iron?

Mr. Perry: One should go to paint manufacturers of established reputation and experience and be willing to pay their price to get the safe percentages and the proper gums dissolved in that oil, or you will get an absolute failure in that you will get a varnish that will not stand exposure.

Mr. Warder: It will not do, then, to simply take a varnish and mix it in with your paint?

Mr. Perry: No, you are correct in that.

Mr. Finley: You spoke of using lacquer as a shop coating. Is it possible to apply that to the iron or steel in bridge shops? Do you get a good result in such a case?

Mr. Perry: The suggestion which I made to-night and which I have carried out in tests was the use of a very limited amount of those resins, or compounds of chromium, not exceeding 5 per cent., of those materials to form a sort of lacquer on the iron, with no thought of its permanence. It is safer to put on a material of that kind, rather than a cheap dope which will cover up the defects of the iron so the purchaser cannot see the quality of material he is getting.

Mr. Finley: Of course, all engineers know that linseed oil does not give protection for any great length of time. A few years ago it was customary to put a coating of linseed oil on iron to protect it pre-

vious to its use, but if any length of time elapsed before the iron was used the fact was disclosed that linseed oil did not offer any protection. The question in my mind is whether there is any particular advantage in using the lacquer over the oil.

Mr. Perry: I know the lacquer will give greater life and greater impenetrability during that life which is short. It is sufficient for any reasonable time until the job is ready for the material.

Mr. Finley: Would you recommend any particular paints for the first coat, and other kinds of paint for additional coats? Could you get any better results?

Mr. Perry: It has been suggested by Dr. Cushman that a strong inhibitive priming coat should be put upon the structural steel on a job, and then follow that with final coatings that are extremely good excluders. The Committee of Inspection, when at Atlantic City last month, were of the opinion that it would not be safe to recommend that until we have made exhaustive tests to determine whether the difference in elasticity would render it unsafe, etc., and whether the difference in constitution of the final coatings might not introduce a danger. There would be a tendency for the material to create in themselves an electric tension, through which, in the presence of the moisture, considerable pitting would be created. We are going to make a series of tests on these very questions you have brought up.

Mr. Layfield: Is there any reason to suppose that the pigments which are the best inhibitives as shown by this test, would be the best in resisting locomotive gases?

Mr. Perry: In other words, you wish to know whether those materials which are known to create a passive condition of the iron—which inhibit corrosion or retard it—will do so in the presence of actual acid gases. They will, and I would like to have Mr. Gardner take that matter up for you. He will show you just why they will do so.

Mr. Gardner: If a plate of iron or steel is placed in a jar containing a dilute solution of potassium bichromate, there will be no corrosion taking place. If to this solution of bichromate is added a weak acid in small percentage, the stimulating effect of the acid will be overcome by the inhibiting effect of the bichromate.

Mr. Layfield: Mr. Finley's remarks have reminded me of another point. Is the zinc chromate as good an excluder as the graphite?

Mr. Perry: In answer to that question I will say no. I am glad that point was brought up, because some paint manufacturers, without a proper knowledge of the subject, have the idea that because zinc chromate is good in a small percentage, it will therefore be good to make a paint out of it entirely. We do not say it is a bad thing, but we deal only in what is good, and we do not recommend it. $2\frac{1}{2}\%$ to 5% of the zinc chromate will give the desired inhibitive values. Anybody can put it in paint if it is specified.

Mr. Warder: Suppose you have a supply of paint of which you

are a little suspicious. Can you make use of that paint by adding to it some of this zinc chromate?

Mr. Perry: If you are suspicious of a paint I would suggest that you give it to your colored man.

Mr. Layfield: By putting zinc chromate in graphite, would it make the graphite more inhibitive?

Mr. Perry: You might stimulate the effect of the graphite and create deep pitting.

There is this to be said about graphite paints. While we know they are sometimes extremely poisonous, we often find the steel in very good condition after the graphite has been on for a long time. We know they are good excluders and water shedders.

It may interest you to know that the American Metal Workers' Association at their Buffalo meeting passed a resolution, through their committee on protective coatings, which was unanimously adopted, warning their members against using the graphites and blacks on metal. That is a matter of record, and it is also quoted in the scientific bulletins. The men who are advertising graphite do not advertise this fact, but those metal workers represent practically a "rule of thumb" method of experience from one ocean to the other.

Mr. Bainbridge: Do not some of the graphite manufacturers put zinc chromate in their product to make the color green?

Mr. Perry: Zinc chromate is quite expensive, and has never been used for any such purpose, because the graphite manufacturers are making the cheapest paints on the market. They use greens, but they are the greens that chemists use, not the zinc chromates. A very small percentage of the latter costs perhaps 8 cents per gallon of paint which is expensive.

Mr. Bainbridge: I have here a sample of iron which was put into the Missouri river in 1863 and was exposed to the current all those years—45 years. On this side, where it was against the crib, it was never painted. The other side was painted with one coat of red lead. The iron had been out of the water two or three days before I saw it, but there was quite a bright coat of red lead on it. The other side was not rusted so very badly.

Mr. Finley: Before that was put in the crib it was used on the Chicago Union Railway as a strap rail, so it had been subjected to considerable use in the way of having railroad trains running over it before it was placed in the crib.

Mr. Gardner: That was probably the Swedish charcoal iron which I spoke of as being used in the manufacture of wire fences twenty years ago.

Mr. Bainbridge: No, it was not charcoal iron; it was rolled in Buffalo.

Mr. Finley: That iron was rolled in the days when they made good wrought iron.

A statement in the first part of this paper to the effect that rusting is due to inferior material in the iron, or the lack of coating with

zinc, brought to my mind something I saw in one of the magazines that on the Isthmus of Panama the galvanized iron sent there by the French was still in a good state of preservation, while the galvanized iron and steel sent there by the United States rusted within six months. Is that due to the material or the coating?

Mr. Perry: It is due unquestionably to the material and the coating. Take two wire fences, each of exactly the same metal—one well coated and the other poorly coated with the zinc. You will get greater corrosion and more rapid destruction of the fence poorly coated. The coating is, however, not so marked a factor in the rapid destruction of the wire fences to-day as the poor metal used in making those fences. In these days, under the great stress of competition, manufacturers have made use of extremely unsatisfactory metal in turning out the great tonnage of these woven wire fences.

Mr. Finley: I can imagine that poor coating is made use of also.

Mr. Perry: Yes, the same men who furnish the poor metal are apt to put on a poor coating. In some parts of the West the wire lasts only three years. On the other hand I examined a fence recently in Georgia which was bought and erected by Hamilton Yancey shortly after the war. His grandson has removed it to another part of the plantation, and it is to-day in an excellent state of preservation. Some of the fence was galvanized and some was not.

Mr. Finley: Was the ungalvanized fence unpainted?

Mr. Perry: It was unpainted.

Mr. Finley: What we need is good iron rather than paint.

Mr. Perry: If you had good steel many of your problems would disappear.

Mr. Finley: I should think that the poorer the steel the better the coating that would be necessary.

Mr. Perry: There are extensive tests going on at Pittsburg, which are primarily under the direction of the Department of Agriculture, and we, together with the steel companies, are collaborating in that work. The tests are in connection with woven wire, and we are testing out these problems.

Mr. Chamberlain: What Mr. Perry has said with reference to some structures which were painted with graphite paint being found to be in extremely good condition reminds me of a little experience which came to my notice a number of years ago. Some practical tests were attempted on a railroad with which I was connected at that time, in the way of painting steel plates or wrought iron plates—with different paints and subjecting them to the practical tests of receiving the fumes from the locomotives in train sheds and *through* bridges. The plates were hung up on some of the bridges along the road, and also in a large train shed and examined from time to time. While I had no direct supervision of the work, I remember the test very well. One of the paints that was considered good in its protection of the steel was graphite, and another was one that was called a rubber paint. These two paints were among the paints most

severely condemned by the chemist of the road. It seems to me the practical tests in graphite paint or any other paint ought to, in a measure, confirm the diagnosis of the chemist in the matter.

I do not think Mr. Perry explained why, in some cases, the graphite paint did seem to take well and in other cases it did not; in other words, it aided in the corrosion.

Mr. Perry: If, as between two tests, in one the graphite shows protection and in the other the graphite has failed, we still are not certain that the metal is a constant in its quality. Or, to reverse the matter, if the metal is a constant, we are not certain that with two graphites you will get different results. The trouble has been that too little attention has been paid to this subject in getting absolutely uniform conditions under which to make these tests, so you can be sure of your conclusions. The whole art of the paint manufacturers was a "rule of thumb" method, and it is only within recent years, when structural iron and steel means the investment of immense sums of money and the reputation of those in charge of that work, that we are addressing ourselves properly to this problem of discovering the conditions under which the tests are made, so we can draw safe conclusions. Thus far, where all conditions of the tests are known, the graphite has not given good results.

Mr. Houston Lowe (Dayton, Ohio): The electrolytic theory of corrosion is interesting and plausible; however, the fact that electrical attraction and chemical affinity are one and the same may be at times disregarded. My own thought is that the inhibitive action of zinc chromate is due to the fact that it is slightly soluble in water, and as the essential property of paint pigment is insolubility, Mr. Perry's advice, that it be used sparingly, should be followed. The commercial varieties of zinc chromate may contain small amounts of impurities, which may cause it to stimulate rather than prevent corrosion. Its quality is dependent upon the material from which it is made and the method of manufacture.

I do not agree with Mr. Perry in his statement that as a general proposition the natural iron oxides should be used for protective coatings, unless he will qualify his words to mean natural ores roasted.

Mr. Perry: I want to agree with you on that.

Mr. Lowe: In regard to Mr. Finley's remarks about salt water drip: Although this is undoubtedly a more active agent of corrosion than fresh water, yet it has been my experience that salt water has less effect upon dried paint than has rain water. It is the mechanical abrasion due to the drip from refrigerator cars that injures the paint coating, and its disintegration is further due to the action of the water lodging and evaporating upon its surface. So soon as the continuity or the integrity of the coating is destroyed, the corrosion of the exposed metal is rapid. Railway companies could save money by frequently touching up those portions of steel structures that are subjected to special injury of this kind.

Graphite paints of certain kinds have at times given excellent results in protecting steel, therefore it seems possible that the action of the American Metal Workers' Association in warning its members against the use of carbon paints on metal was somewhat hasty. It may be well to recite to you my conception of the factors that affect results in painting, namely:

1. The location of the structure.
2. The kind and condition of the surface over which the covering is spread.
3. The weather conditions when painting is done.
4. The quality and temperature of the paint.
5. The workmanship of the painters.
6. The number of coats applied and their sequence.
7. The time allowed to elapse between coats.

Neither the manufacturer, the architect nor the engineer can confidently predict results without knowing each of these things.

Mr. Finley: Would you say the more coats the better?

Mr. Lowe: Yes, generally, up to five coats. Linseed oil does not reach its most stable condition under several weeks after it has been applied. Dried linseed oil gets better and better up to a certain stage, and then it begins to deteriorate.

Mr. Perry: I want to thank Mr. Lowe for what he has said. He is a man has spent a life time in this work and knows whereof he speaks. I want to endorse Mr. Lowe's statement in the matter of graphites, and that there are many other things or conditions than the paint also to be taken into consideration, and one must be sure that these conditions are exactly uniform.

Mr. Layfield: I got the impression from what Mr. Lowe said about the oil improving for several weeks, or even months, after it was applied, that he might mean that that time should elapse between coats.

Mr. Lowe: I do not know, but I believe that if you can allow a month between the application of the different coats of paint on a bridge, you will get much better results than you are now generally getting.

I may speak of steel underground pipe. While the relation of carbon to iron is undoubtedly an established one, yet my experience has been that if an underground pipe coating is made from gilsonite and linseed oil, it will prolong the life of the pipe many years. I think Prof. Sabin will give similar testimony. The result depends largely upon the temperature and the conditions under which the material is applied. It should be applied rather hot, and the temperature of the metal should be about that of the liquid, otherwise air bubbles will be produced. Then my experience is, too, that it is better to bake it at a moderate temperature, after it is removed from its bath.

Mr. Perry: I would like to add, in connection with Mr. Lowe's remarks, that I heartily recommend gilsonite under these conditions.

WATER STORAGE IN ELEVATED TANKS AND STAND PIPES

H. E. HORTON, M.W.S.E.

Presented, February 3, 1909.

The advantage of water stored at an elevation is recognized by all as desirable; to fit to the varying local conditions many expedients are resorted to. We have under discussion the use and advantage of the elevated tank and stand pipe.

It may be interesting to notice the evolution from the wood tank on a low trestle, as so universally used for water supply to the railway locomotives; placed upon a higher trestle for a small town's water supply, this trestle as time went on being substituted by metal, and following this the tank being made of steel; all in the same line of evolution and about the same time that bridges and cars changed from wood to steel.

Occasionally there is suggestion of building elevated water storage in reinforced concrete. However, as it takes the same amount of steel to reinforce the concrete that it does to hold the water without the concrete, it has only been used where there is an apparent intensity of desire for the truly unique, and for the purpose of this discussion we will ignore it.

A stand pipe, open at the top, of small diameter was an attachment to large pumping works at a very early date, to relieve the water hammer on the pumps. We have in Chicago the water tower at "Chicago Avenue" and "Ashland Avenue" Pumping Stations, as examples.

Mr. Cook of Toledo, Ohio, some forty years ago was, I believe, the originator of a system of water works for small towns wherein with a moderate sized pumping engine, the stand pipe was materially enlarged; thereby providing storage under pressure (the advantage being the relief from continuous pumping) and the stand pipe came into very general use for such locations as fitted for,—a level town or small city.

The term, stand pipe, as here used, defines a class of structure say 10 ft. to 30 ft. in diameter with heights equal to 3 to 12 diameters. Such a structure has its limitations as to economy of construction.

The largest examples of metal tanks (not known as stand pipes), to hold water that have come under my notice are those for making the water seal of gas holders, where tanks of some 200 ft. in diameter and 50 ft. high have been used and as stresses in the shell = radius $\times$ water pressure—it follows that in all tanks or stand pipes the stress in the unit of the material is as the height multiplied by the diameter, hence a tank 40 ft. in diameter and 250 ft. high would have the same stress in the material as for the one indicated above and would be something over 25,000 lbs. per inch vertical near the bottom of such tank, and material must be provided for normal unit stresses, of over 2 in. in thickness.

Now as it happens that water stored for purposes like fire protection in its various demands, such as sprinkler systems for fire extinguishment or regular town water works, water is frequently required at considerable elevation and with the least range of varying pressure; in fact an absolute uniform pressure would be ideal. This is impracticable, hence we must allow at least 10% of the extreme height for a varying pressure.



70,000 Gals.—100 ft. High.
Highland Park, Dallas, Tex.



70,000 Gals.—220 ft. High.
Rutland, Vt.

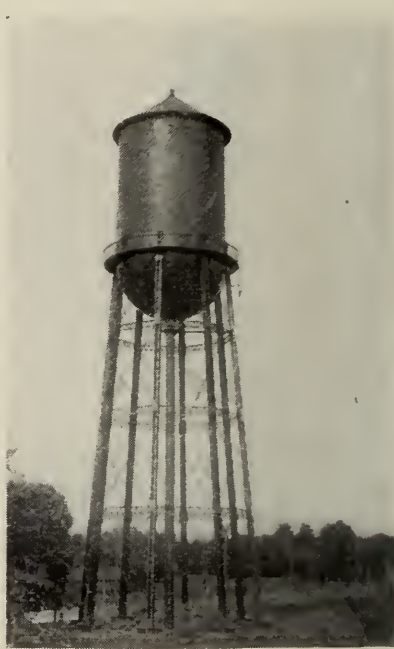
From estimates covering a large number of examples with limitations as above, it may be asserted that with a low elevation like a mere flat tank, a tower is at a disadvantage, but when the average elevation of water required is 100 ft., it will cost twice as much to store it in a stand pipe as in an elevated tank. Again it may be wanted at an average elevation of 150 ft., if so it will cost three times as much to store it in a stand pipe as in an elevated tank. When wanted at 200 ft. average elevation it will cost four times as much to use a stand pipe as the tower and tank. At 250 ft. average elevation it will cost five times as much in a stand pipe as in a tower and tank. At 300 ft. average elevation it will cost six times as much to use the stand pipe design as a tank. From all the above, it is apparent why towers and tanks have come into use for storage of water, where potential energy of the water is a matter of consideration.

The tower to support a tank may be readily designed with three or more supporting legs. The foundations for such tower and the

stresses from wind are well worked out in connection with the elevated skeleton structures so frequently seen on our railroads. Local conditions must determine the character of the foundations. The batter of the legs will usually be such that the uplift from the wind on the windward side (and tank empty), is abundantly provided for by convenient anchorage. It will be found an advantage to place the legs of such a tower radially from the center, so all the legs will be alike for convenience in manufacturing.



185,000 Gals.—120 ft. High.
Vineland, N. J.



200,000 Gals.—220 ft. High.
Louisville, Ky.

The tank itself may be a cylinder with a flat bottom placed upon a platform built of beams. This class of design will invariably be over costly; the relation varying somewhat as the diameter to height of tank varies. Preferably the bottom may be conical or hemispherical, made of plates only; in fact combinations of the spherical combined with the conical, have been worked out to relieve the excessive stresses developed at the intersection of the cone and cylinder. It is somewhat the personal equation of the designer that determines how this part of the design shall be carried out.

At the point of attaching the tower to a tank it is quite the usual practice to use a horizontal girder strong enough to take up any tendency to deform the cylinder by the horizontal components of the supporting posts, hence it will be observed that this girder is of much greater importance on a tank supported with three posts than if the same tank was supported by six.

From conditions as herein indicated there has been much discussion and variation in design in placing a tank with a conical or

spherical bottom on a tower. Many designers believing it is a necessity to extend the cylindrical part some distance below the water level and look at, and think of, this extension as a *circular girder*, while others have treated the entire depth of the cylinder of the tank as the web of a circular girder. Sufficient to say that there is no difficulty in making an efficient design either way.

Some engineers feel a greater satisfaction in designs so developed as to present a multiple number of supports from the tower to the tank, which to all of this, there is no objection other than the one of increased cost. The best results with least cost will always be found with a standard design.



115,000 Gals.—127 ft. High.
Monmouth, Ill.



300,000 Gals.—131 ft. High.
U. S.—Ft. Snelling, Minn.

The tank must hold water. Tight work has to be developed. It will ordinarily be found to great advantage in construction if a close study is made of the joints and their disposition to the end that rivets will not necessarily go through a large number of plates and that caulking edges be so arranged that the same may be gotten at to caulk and make the work water tight.

The tank on such towers is usually supplied with water by a riser pipe up the center of the tower. This riser pipe is enclosed in a frost casing some three or more thicknesses of lumber, about which "building felt" is freely used.

For sprinkler tanks, where water merely stands in the tank, in this climate they will have to be supplied with artificial heat. This may be accomplished by a moderate sized water heater directly con-

nected with the riser pipe, or with live steam, if the tower is so situated that live steam is available.

If the tank is in general service, like a town's water works and the service is such as to require say one hour's pumping in the morning and one hour in the evening, a very moderate sized works will require no further attention as to freezing.



50,000 and 75,000 Gals.—71 ft.
and 130 ft. High.
Factory Power Co., Cincinnati, O.



112,000 Gals.—162 ft. High.
Lackawana Steel Co.
Buffalo, N. Y.

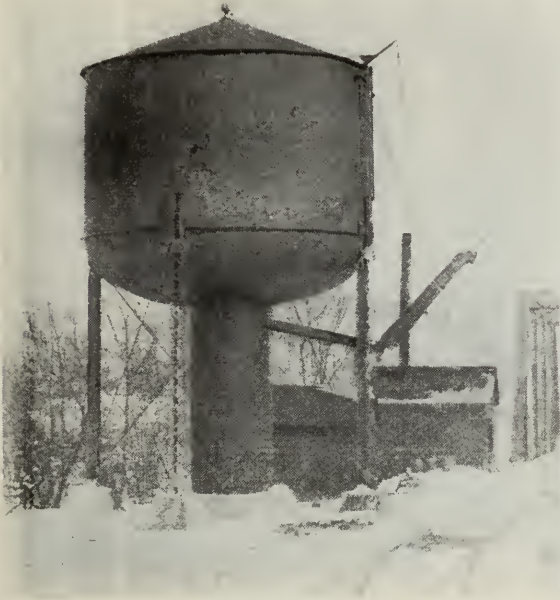
I do not wish to be understood as advocating the use of an elevated tower and tank in connection say with a hill, to put an ordinary earth reservoir in, or to place a flat metal tank on, provided said hill is within convenient reach from both the pumping station and the point of consumption. Each location presents a problem.

When not favored with a convenient natural elevation, the elevated tank offers to average communities, water storage, so that the pumping plant requires to be in actual operation only some small portion of each 24 hours and one force of operators can maintain the works, thus making it possible for many small towns to maintain and operate water works that otherwise could not because of the operating costs.

Examples without number have come under my observation of the reduced expenses where a tower and tank has been installed, where work has previously been done by direct pressure from the pumps. In the City of Chicago, at the Washington Heights Pumping Station, while the full force of men have been maintained, the quantity of

coal was reduced approximately $\frac{1}{3}$ upon the installation of the elevated tank.

At Paris, Ill., the city had operated a direct pressure pumping plant for 20 years, and with a double set of operators, when in 1895 an elevated tank was attached to the system with a result that at once one set of operators was sufficient to continue the work; in fact the entire cost of operation was reduced 40%.



60,000 Gals.—35 ft. High. C. P. &
St. Louis Ry., Lock Haven, Ill.



100,000 Gals.—150 ft. High.
Hospital for Insane,
Columbus, O.

At Galion, Ohio, a franchise company after running the pumps for direct pressure for 25 years, introduced an elevated tank and the cost of their operations was reduced $\frac{1}{3}$ with a much more satisfactory and uniform pressure for the town. The list of instances of advantage as here indicated, could be extended almost without limit.

Of the stand pipes built in other years a number of somewhat startling failures have occurred. Reviews have been made of the structures that failed and it seems to be noticeable that there were fairly high unit stresses involved in all cases.

In years past little attention seemingly has been given by designers of stand pipes to the efficiency of the rivet connections. In analyzing this question of efficiency of connections we assume that rivet shear is equal to $\frac{2}{3}$ the tension value of the material, and it is not unusual to find stand pipes with rivet efficiency of no more than 30% of the value of the plates.

The question of rivet efficiency in anything like boiler or tank work, is of paramount importance. While it is possible by double butt strap joints to make a rivet joint of more than 90% efficiency, yet due to the added weight of material as well as cost of labor, it may be doubted if there is any advantage in attempting to develop efficiency to exceed 80%. In fact, in moderate sized tanks, something like 70% efficiency will quite likely work out, the most satisfactory. Experience seems to justify the use of lap joints on material up to say $\frac{1}{2}$ in. thickness.



75,000 Gals.—91 ft. High.
Edmonton, Alberta, N. W. T.



125,000 Gals.—135 ft. High.
Can. Pac. Ry., Winnipeg, Man.

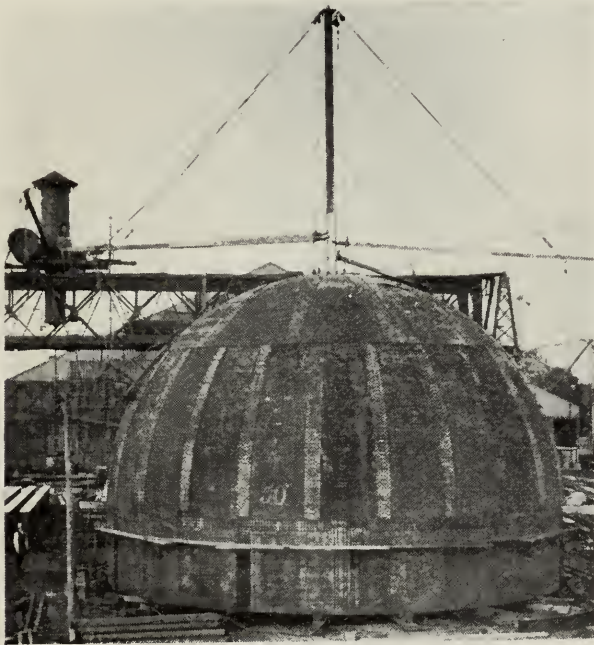
There never has been a failure where the stresses on the efficiency of the joints in the stand pipe were as low as 15,000 lb. per sq. in. and larger numbers of pipes are standing and have stood for a long period of years where the stress on the efficiency of the joints is over 30,000 lb. per sq. inch.

The group of stand pipes referred to above, were designed on a basis of gravity stress of about 15,000 lb. per sq. in. of the gross section of the plates. That the mortality has not been more serious is surely a kind interposition of an over-ruling Providence. While there may have been bad material and bad workmanship, there has also been most unfortunate designing. To such designs the failures must be charged.

Towers and tanks have a better record as to their mortality. In fact, very little in the way of failure or criticism has presented itself. There have been examples of conical bottoms attached to the cylindrical part with a moment on the joint. Great difficulty has been experienced in keeping such joints tight, and the one only very con-

siderable failure of a tower and tank has occurred from this fault in design.

It is my pleasure to present to you some illustrations of sundry examples of elevated towers as constructed. These have been selected as showing a variety of use as also a variety of structures.



Louisville, Ky., Tank Bottom 50-ft. Diameter.



22-ft. Sphere at St. Louis Exposition.

We have the tower and tank with sundry expressions of architectural effort and atmosphere; all of which reminds us that the personal must have consideration and the further very interesting fact that there is no gauge in the matter of taste.

We have a tank with elaborate protection against the cold in the extreme north. We have them with no protection in the south.

The towers and tanks shown are in use for :

- City Water Works.
- Public Institutions.
- Private Estates.
- Industries.
- Railroads.
- Hydraulic Works.

with examples of :

- 3 supports to tank.
- 4 supports to tank.
- 6 supports to tank.
- 8 supports to tank.
- 12 supports to tank.

also the :

- Flat bottom tank.
- Conical bottom tank.
- Hemispherical bottom tank.
- Semi-elliptical bottom tank.

We also have a lantern slide showing a 50 ft. diameter tank bottom fully assembled in the yard for reaming 15,000 radial holes through approximately $1\frac{7}{8}$ " from $1\frac{1}{16}$ " to $1\frac{1}{16}$ ".

In the matter of spherical work, the surface cannot be developed, while the cylinder or cone may be. The difficulties of mechanical execution are such as to generally preclude the use of the sphere or sections thereof in plate metal construction.

The only interest attaching to the complete sphere, that is, two hemispheres connected by an equator to show the mechanical skill with which this work was formed so rivet holes upon parts being assembled showed fair throughout. This picture is of an exhibit at the St. Louis Fair in 1904.

DISCUSSION.

President Allen: In traveling through the West the elevated tank structure has become quite a feature of the landscape. Many parts of the country are not favored with natural storage at the proper elevation, and even where such locations are supplied by nature, we are often presumptuous enough to believe that we can improve or cheapen the primitive storage.

The uses of elevated water storage are many: first, and probably most important, for water supply; then, in addition, we have the industrial uses which Mr. Horton has indicated; and then for the sprinkler systems, and railroad storage; this last is a problem by itself.

Many of us will no doubt be glad to hear that the building of elevated tanks and supporting structures is one branch of engineering work into which reinforced concrete, in the opinion of the author, is not entering with success and where it still may be designated as "unique."

In our discussion this evening I hope that members who are familiar with any particular class of water-storage will add what they can to the subject from their own standpoint. I also hope that the discussion will cover, or at least touch upon, the failures of water-tanks and stand pipes. We do not seem to learn very much as long as all our efforts are successful, and we generally have to pay in failure for the knowledge we acquire, as has been impressively shown in the case of the Quebec bridge.

Mr. O. E. Strehlow, M.W.S.E.: The only stand pipe that I have ever had anything to do with was a freak. It was a 20,000 gallon tank 100 ft. high, built for a sprinkler system. The principal thing aimed at by the designer was to have the arrangement such that two men could do the erecting; one of the men was picked up where the tank was built and the other sent from the shop. The different parts were small enough to enable two men to handle them. The tank was made of cypress and the tower was steel; the posts were of such length that they could be easily handled, being $6 \times 6 \times \frac{3}{4}$ in. angles, provided with a loose sleeve or casting at each joint so that the next section could be slipped in and then properly braced with rods, angles, etc.

I was called upon to ascertain whether the tower was sufficiently strong or not, and found that if the tank was full of water the tower would fail, and if empty the wind would blow it over. I told them to keep 4 ft. of water in the tank until the tower was properly reinforced. I believe the tank is still standing and that it is giving satisfaction.

Mr. T. W. Snow, M.W.S.E.: I have been much interested in listening to Mr. Horton's remarks and also seeing illustrations of a very modest representation of the great number of tanks he has erected, for if you were to travel through the country you would see simply thousands of them; it is hard to tell where the tank leaves off and the horizon commences.

Mr. Horton is an advocate of an idea in which I have been interested in one way and another, and that is, if one is going to store water at an elevation the water should be stored in as large and compact a body as possible.

I was impressed with Mr. Horton's remark that the principal

feature in connection with a tank is that it should hold water. I thought that idea was an excellent one.

Some forty-five years ago was the beginning of putting up vertical tubes for water-tanks. I believe Prof. Pence has a record of about ninety-two failures of those stand pipes, and it was not until after a number of failures that the engineering profession took the alarm. I will call your attention to a few places where failures occurred; Elgin, Peoria, and Kankakee, in Illinois; Providence, Rhode Island; and Lancaster, Ohio. There were many other failures as well. As far as I can tell they were from one cause only,—from a heavy ice-cake forming in cold and freezing weather. The operation was something like this: The city would put up a tank, say, one-hundred feet high and about twenty feet in diameter, which is about the capacity for a town of 25,000 people. The tank was supposed to be kept as near full as possible. In severe weather a heavy ice-cake would form—thick at the top and diminishing in the shape of an inverted hollow cone, on the inside. Naturally the accumulation of ice would become thicker and thicker at the top while it would not be so thick at the bottom. In January when there is usually a thaw, this ice-cake would loosen on the inside of the tank and perhaps become free all the way around, especially if there should occur at that time a warm south wind. When this mass of ice was loosened, (and it would loosen just as soon as the consumption would lower the water level), this mass of ice would fall and almost invariably it would cause the destruction of the tube. For that reason the tubes were considered dangerous and they are almost obsolete now. I know that many were taken down before they failed. At Batavia, Ill., one was taken down that had been up for fourteen years. It was probably condemned, not for any ice formation, but for natural oxidation, assisted perhaps by some sulphur in the water. We are now having poor water service at Batavia to what we had before, but we are safe.

In putting up elevated structures such as Mr. Horton builds, due regard should be paid by the engineer to the amount of consumption, both night and day. I do not know of the failure of a single tank as described by Mr. Horton, from ice or any other cause. They are not old enough to fail from age and I do not believe there will be any failures on account of the ice-cake. The bulk of the water, and greater diameter as compared to the height, will necessarily lessen that danger. Great care, however, should be paid to the protection of the riser-pipe for all ordinary towns, or there should be a bleeding-pipe to keep up the circulation. The loss of water through this leakage is small as compared with the damage from freezing. The lagging that is put around these pipes should have, in addition to the wood, from two to five air spaces. The expense of doing this is not at all serious, and this protection should be well built.

President Allen: I will ask Mr. Snow what the ratio should be

between the diameter and height, in order to avoid the danger from ice that he mentions.

Mr. Snow: I do not know that I quite understand you, and if I do understand you, I do not know.

President Allen: You spoke about the failures occurring with high stand-pipes and stated that no failures had occurred with more compact storages at similar height. Therefore I gathered that in your opinion the immunity from failure might be largely due to a correct proportion between the diameter and height. Is there any ratio that can be taken as a safe one to avoid that danger?

Mr. C. B. Burdick, M.W.S.E.: Perhaps I can throw some light upon the matter. It is my understanding that Mr. Horton has designed and built the majority of the elevated tanks in use and that he confines himself largely to this type of structure. Possibly this accounts for the success of the elevated tank.

In view of the reference made in the paper to reinforced concrete tanks, this may be a good opportunity to bring out the defects in that kind of construction. The reinforced concrete tank is a new proposition. It has been only about five years—perhaps less—since the first one was built and there are very few in use at this time. The circular water-tank offers, at first thought, an unpromising field for this line of construction in view of the fact that the stresses in the shell of the tank are entirely tensile. The concrete takes no compression as it does in the ordinary concrete construction. It is therefore necessary, in a stand-pipe, or tank, to take all the stress in the steel, and therefore the cross-section of the steel must be practically as great in the reinforced concrete tank as in the steel plate construction. There is, however, this difference; the plate construction costs in the neighborhood of five or six cents a pound, whereas the concrete reinforcement steel can be put in for about half that sum. In structures that have been built the cost including concrete and steel has not been materially different from the cost of reasonably designed steel structures for the same service. In steel tank construction it is considered good practice to limit the tensile unit stress to about 10,000 lb. per sq. in. net section, owing to the effect of ice. It seems reasonable and experience has apparently demonstrated that in covered concrete tanks, ice formation is so small as to be negligible and therefore higher unit stresses are probably justified than would be permissible with steel plates. The use of reinforced concrete in tank construction has been applied not only to the stand pipe but to the elevated tank. The object of the concrete in reinforced structures is simply to hold the water and transmit stresses to the steel. Concrete is not an ideal material for holding water. We have been able to construct concrete reservoirs in the ground with success, but in the elevated tank or stand-pipe a much greater water tightness must be secured, inasmuch as a small moist patch on the outside of the structure will ruin the surface through the action of frost. It is the problem of making concrete

impervious that offers the greatest difficulty that has been encountered in the use of this material. In the tanks that have been constructed much difficulty has been experienced in making them watertight, but I am informed that the matter has been successfully met in a number of instances.

It seems to me that the matter of appearance is quite important in a structure of this kind, for, as has been said, it is a feature of the landscape from almost every point of view. It is one of the most difficult engineering problems to treat in a manner pleasing to the eye, and some of the efforts of engineers to make a structure of this kind beautiful are rather doubtful. It seems to me that the reinforced concrete stand pipe offers a more promising field in this respect, and if a tank of this material can be constructed so as to be conservative and safe at a cost comparable with steel, from the standpoint of looks it deserves some considerable recognition. The matter of durability is also, I believe, in favor of concrete construction and that is something which should not be overlooked.

Mr. Snow: In California there is an 80 ft. reinforced concrete tank, with a capacity of 100,000 gallons, which has been standing about three years, and I understand it is giving satisfaction.

Mr. J. N. Darling, M.W.S.E.: In connection with the remarks of Mr. Snow relative to failures of stand pipes, it may be interesting to note the failure of a stand pipe at Murphysboro, Illinois, in the winter of 1898, at a time when I chanced to be in that town.

The stand pipe was about 100 ft. high and about 20 ft. in diameter, and situated on a hill just outside of the town. Immediately following an exceedingly cold spell, during which a thick coat of ice was formed, there came on a thaw which probably loosened the ice causing it to crash to the bottom. At any rate the pipe collapsed. On viewing the wreck next day, I found that the steel plates near the bottom were torn apart like paper, this tearing of the sheets was on the south side of the base; and the stand pipe fell bodily to the north. Sheets of ice from the interior of the stand pipe were lying all about, showing how generally the ice had been loosened.

Mr. W. W. Curtis, M.W.S.E.: In 1884 I was in the employ of Mr. C. F. Loweth, who was then a Consulting Engineer at St. Paul. In 1886 we became partners under the name of Loweth & Curtis. In the spring of 1887 Mr. Loweth was obliged to be away from St. Paul for sometime, and before leaving he advised me that he had agreed to prepare plans for a water-tower for the city of Cedar Falls, Iowa, by a certain date, and asked me to get the design ready. I found that his ideas were a wooden tank of 100,000 gallons capacity, to be carried on a brick or stone tower 70 or 80 ft. high. After drawing up three or four designs, I adopted one which I thought might come within the limits of the available funds, and went to Cedar Falls to receive bids on it. Unfortunately, however, the contractors' ideas as to what that stone-work was worth differed so much from mine that we could not come to any agreement, and

I went home very much disgusted. In talking the matter over with Mr. Loweth we decided to see what we could do with a steel supporting structure for the tank. A steel tower was then designed using four posts, and the same size of wooden tank at the same elevation, and soon after contracted for. This, so far as I know, was the first tower of that kind to be used in this country. I looked the matter up carefully at that time and found there had been a few elevated tanks used abroad, and I think one or two had been used in this country, but in each of these cases, as I remember it, the structures were extremely expensive, and supported on masonry towers.

Later on, when Mr. Loweth and I were working independently, we built a large number of those structures in different parts of the northwest. Some were wood tanks on steel towers and some wood tanks on wood towers, as necessity for economy in first cost, dictated. In each case, the condition of concentrating the water where it had some value for fire protection was maintained. In 1890 I built such a tower at Albert Lea, and there used a steel tank with a flat bottom, necessitating, of course, a great many I-beams to carry the bottom. That tank I understand is still standing. I used a number of stand pipes at that time but believed then, and believe now, that, in its proper place, there is no method by which a reasonable amount of water can be stored more economically than in a steel tank on a tower. I have not yet discovered the real logic of putting a stand pipe perhaps 100 or 120 ft. high on a location which is practically no higher than the site of the town, and then having no protection, as far as fire is concerned, from a large part of the stored water. There was another drawback to the use of stand pipes, however, and that was, that any person who had a plate-bending machine could build a stand pipe, whether he knew how or not.

I designed a beautiful water-tower with curved posts for Monmouth, Illinois. The town is flat and the location selected for the tower was in the center of the town. The difficulty I encountered was that every man who could build a stand pipe was arrayed against me. The arguments that were used to demonstrate to the City Council that I did not know my business, that the tower designed was a fake, and that it ought not to be even considered, prevailed against me. Although the design was not accepted I had the satisfaction of preventing the erection of any other design, unadapted to the situation, and the town operated the water-works by direct pressure for a number of years.

For the last fifteen years I have referred anything I might have, in the line of water-towers, to Mr. Horton, and, I am glad to say, with gratifying results to myself and to my clients.

President Allen: More or less has been said here tonight against reinforced concrete tanks, and as we have a zealous advocate of reinforced concrete with us, I will call on Mr. Condrón to tell us what he knows about the success of tanks of that character.

Mr. T. L. Condron, M.W.S.E.: I frankly confess that I know very little about concrete water tanks of the character referred to. I was much interested, however, in what Mr. Burdick had to say about this style of tank.

With reference to the tank in California, referred to by Mr. Snow, that was described in the "Engineering News" during the past year, I think, but I do not remember whether or not there was an illustration of it. I learned recently that the Southern Railway Company is building reinforced concrete water tanks supported on towers, one of which is near Knoxville, Tennessee, with a capacity of 50,000 gallons. There has also been illustrated in the papers within the last year a very interesting example of a pair of reinforced concrete water-towers built at Havana. These towers were built with a dome bottom (instead of an hemispherical bottom turned down), and that feature interested me because in my office nearly five years ago such a structure was designed but not built. The design was a study and was worked out in a very interesting manner to show the possibilities of such a structure.

When this illustration of the towers at Havana appeared in the "Engineering News," it at once showed that our study had been along practical lines.

In St. Louis there is a reinforced concrete tower supporting a reinforced concrete tank, which has been standing for some three years, and so far as I know, it is giving entire satisfaction.

I understand that there is a tank of this character in Franklin Park, northwest of this city, but I have not seen it.

One of the members of this Society has been successful in building some circular reservoirs, standing perhaps 20 ft. high but resting on the ground, with concrete walls 4 ft. 9 in. thick and 50 ft. in diameter. Two or three of these have been built at Lake Geneva, Wisconsin.

Mr. C. W. Naylor, M.W.S.E.: The remarks of one of the previous speakers were to the effect that it is a good thing to cover those outer tanks with lagging. I would ask if it is not desirable to take that lagging off once in four or five years to see if there is any corrosion. It seems to me that after a tank has been under high pressure for fifteen or twenty years, there is danger from corrosion.

Most of the illustrations shown by the author of the paper cover outside views of tanks for all purposes. In the cities we have the sprinkler problem to contend with, and we have not ground space for the tanks, so the water is generally stored on top of the buildings, and the amount of water is often very large. Frequently the columns of a building are not made much heavier than necessary to hold up the building, and the question arises, should a wooden or metal tank be used? In connection with my own work, two or three wooden tanks have been replaced with steel tanks. It is an experiment on our part, for there is some question as to how long the

wooden tank will last. In other words, will a wooden tank be safe at the end of 25 years?

Mr. W. B. Storey, Jr., M.W.S.E.: In addition to the points raised by the last speaker, I should like to hear something in regard to depreciation of those elevated structures both outside and inside; the pitting and rusting of the metal; the character of protection which is applied to save the structures; what effect, if any, the ice may have, and whether there are any data as to when the depreciation is liable to reach a dangerous point.

Mr. Horton: In regard to Mr. Snow's inquiry of the desirable diameter for the storage of water; it happens that ice will form from the outer wall inward and in very cold weather it is liable to form 3 ft. thick. If the stand pipe were 6 ft. in diameter there would be little water left, but if the stand pipe were 30 ft. in diameter there would be 24 ft. of water. In that case the ice becomes directly a protection. This might be illustrated by a case which was called to my attention at Blue Island, Illinois. The stand pipe there was 10 ft. in diameter and 120 ft. high. On an occasion of cold weather and warm weather following very soon afterwards, and pumping in water, suddenly it was discovered that ice was standing up 20 ft. out of that stand pipe. It fell over and demolished a near-by building, but the stand pipe was not injured at all.

The question of inclosed work was brought up; so-called riser pipes are usually of cast iron, and there is little trouble from corrosion of these.

In regard to the question of depreciation,—as a business man I really feel somewhat indisposed to answer that question.

In regard to how long a metal tank may last; a certain railroad company sent to us for some data along this line. The operating force had changed to a large extent, and the shops (that of the Rock Island road at 47th Street) were built so long ago that even I could not remember when they were built. Mr. Clark was the Engineer and had a 50,000 gallon tank built of 3/16 in. plates resting on a brick tower of some 20 ft. height. That tank was built somewhere about 1867, and I have sent men there occasionally to examine it, both outside and inside, and there is still no noticeable deterioration.

I think we all recognize the fact that iron does not oxidize as readily as steel. At one time I built a tank (of No. 16 iron), about 8 ft. in diameter, merely to store water over a boiler. It was used eight years without having to be put out of service on account of rust; there were other conditions that caused it to be put out of service. It is quite likely that there are deep well waters containing destructive chemical elements, yet our observations do not lead to the conclusion that there is any such serious trouble as we have seen from gases of the locomotive stacks upon the metal of roofs and bridges. There is no relation at all. In other words, I feel

that we are justified in claiming that with metal $\frac{1}{8}$ or $\frac{1}{16}$ in. in extra thickness, we may expect long service from elevated tanks and towers,

President Allen: I will ask Mr. Horton what kind of paint he recommends for tank preservation, and if there is any difference in that used inside from that used outside?

Mr. Horton: We use graphite paint, mixing it ourselves with the best oil we can buy, using the same for the inside that we do for the outside.

Mr. M. H. Dance, M.W.S.E.: I would ask what is the annual cost of maintenance of the ordinary railroad tank.

Mr. Horton: I shall have to confess that is a subject which has not interested me particularly.

President Allen: I was about to suggest, before Mr. Horton made his last remarks, that after all the life of a wooden tank depends practically on the life of the steel hoops, and that perhaps the opportunities of protecting the hoops are not so great as the opportunities of protecting the entire steel tank.

Mr. Snow: I am not at all afraid of the wooden tank. In 1887 I built the tanks on the C. B. & N. Ry. coming down from St. Paul to Hinckley. Two years ago I was asked to go over all those tanks and report. They are all standing, although the wooden structures holding up the tanks have been more or less repaired. The tanks themselves are still standing.

A question was asked, in regard to depreciation, which Mr. Horton answered. He referred to a tank which was put up in 1867, and I simply wish to remind him that there is a great difference between the iron furnished in 1867 and the steel furnished in 1907.

Mr. White: With reference to the question of ice formation; in connection with a tank at Cedar Rapids built in 1898, a large quantity of ice fell when the tank contained only about 20 ft. of water. No damage was done, however. The tank was made of steel and there were no perceptible leaks. After the trouble was corrected there was no further difficulty.

I would ask if anyone has any notes showing the results of pitting when river water is used and when well water is used. I have found that the river water pits the inside of the tank to a greater extent than well water.

The durability of the wooden tank depends to a very large extent on the quality of the lumber and the quality of the hoops used. Where tanks have been put up, using the best grade of lumber, they have been known to last twenty-eight years, hoops and all.

Mr. Snow: In regard to the tank referred to at Batavia, the water is charged quite heavily with magnesia and lime. I think you will find that when a tank is holding water of that nature, there will be a deposit of magnesia and lime over the interior, and this affords a protection. As to the ability to protect, I do not think

you will have as much trouble with the outside as with the inside, when using mineral waters.

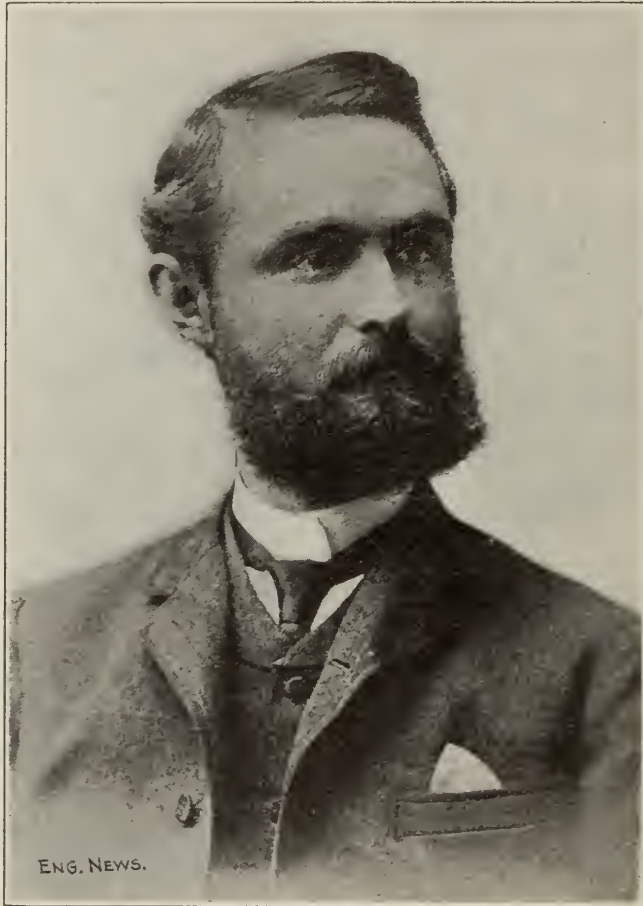
Mr. Burdick: In regard to the effect of water on steel tanks, it has been the experience with water pipes generally that in those localities that have river water or other soft water, the depreciation in the pipes has been most marked. In the eastern part of the United States this is a serious problem and a large amount of money is spent to remove tubercles and incrustations from the water mains, which reduces very materially the carrying capacity of the pipes. The same thing is true of steel tanks. I have noticed in cases where stand pipes have been more or less neglected that the interior of the tank was thickly strewed with tubercles almost hemispherical in shape, and as those tubercles fall off, a pit is disclosed under the tubercles ranging in depth up to $\frac{1}{8}$ in. Where those tubercles are close together it can be easily seen that the cross-section of a thin plate would be quite materially reduced.

This effect of water is quite marked where soft water is stored but usually absent in the case of the harder waters. I believe that any tank should be emptied periodically, examined, and thoroughly cleaned inside and out.

IN MEMORIAM

JULIUS WILLIAM SCHaub.

Suffering from acute melancholia and long continued loss of sleep, in a spell of despondency while returning from a sanitarium in New York where he sought but failed to secure relief, Julius William Schaub ended his life on a railroad train on the morning of March 30, 1909. He had had a similar attack of ill health about a year



Yours truly
J. W. Schaub

ago, when he became unconscious on a suburban train on his way to his home, remaining in a serious mental condition for some time after, but from this attack he had recovered after treatment at a sanitarium in New York, the same establishment to which he went a second time just before his death.

Mr. Schaub was born at St. Louis, Mo., on Sept. 23, 1858, and graduated from the Polytechnic School of Washington University in 1881 with the degree of civil engineer. He was in the employ of the late C. Shailer Smith, the noted bridge engineer and builder, from 1881 to 1886, and employed occasionally as inspector and computer by others in that period of time. He was connected with the building of the bridge over the St. Lawrence River at Lachine in 1886, first in Mr. Smith's office in St. Louis, and then with the Dominion Bridge Co., the contractors. From 1887 to 1892 he was Chief Engineer of the Detroit Bridge & Iron Works; from 1893 to 1894 he was Chief Engineer and Manager of the Pottsville Iron & Steel Company, and from 1895 to 1897 he filled a similar position with the Hamilton Bridge Works of Hamilton, Canada.

In 1898 he came to Chicago and opened an office as consulting engineer in the Monadnock Block. He devoted himself more particularly to bridge and structural engineering, in which line of work he had had a wide experience and thorough training. When reinforced concrete became of importance he interested himself in this type of construction and employed it on original lines. He devised a system of restrained concrete floor construction for buildings, for which the concrete was made to act as a groined arch, with the steel floor beams at the columns forming the four sides of rectangular panels, these floor beams taking the tension from the thrust of the diagonal lines. He made tests at the North Works of the Illinois Steel Company which proved the correctness of his theories. He devised and patented an improved method of sinking open cofferdams of reinforced concrete, and applied this in the building of the new bridge for the St. Louis & Southwestern Railway across the Red River at Shreveport, La., for which work he was consulting engineer. This bridge was completed in March, 1907. It had four fixed spans of 200 ft., one of 150 ft., and a swing span of 300 ft., and the pier foundations were sunk to depths of 60 ft. to 80 ft. by Mr. Schaub's system. He also designed and patented a concrete roadbed for railways, described by him in *Engineering News* of November 2, 1905.

Mr. Schaub's work as a bridge engineer was important, and he was considered a very skillful designer. He was employed in the capacity of consulting engineer by the St. Louis & Southwestern Railway above mentioned, reporting on all its bridges, and preparing plans for strengthening them, also by the St. Louis & San Francisco, the Missouri Pacific, the St. Louis, Iron Mountain & Southern, the Iowa Central, the Minneapolis & St. Louis, and the Grand Trunk Railways. For some of these companies he designed their shops as well as their bridges. His last work was the designing of a large swing bridge for the Grand Trunk Railway at Black Rock Harbor, Buffalo, New York, this bridge forming a part of the International Bridge. The new bridge will carry two railway tracks and two roadways, it will have a length of 431 ft. 5 in., and in the opinion of

the chief engineer of the Railway Company, Mr. H. G. Kelley, is a master piece of bridge designing.

Mr. Schaub became a Junior of the American Society Civil Engineers in 1884 and a full member in 1886. He became a member of the Western Society of Engineers in 1902. He was a member of the American Railway Engineering & Maintenance of Way Association and of the Engineers' Club of Chicago. He was a frequent contributor to engineering literature, writing a number of papers for engineering societies and taking an active part in discussions.

Mr. Schaub married Miss Harriet Holmes of Lock Haven, Pa., in August 1893. His wife survives him, without children, and a sister, Mrs. Emma Rauch of St. Louis.

Mr. Schaub was a man of fine attainments and ripe experience as an engineer, high minded and warm hearted as a man, and his loss by death is deeply regretted and keenly felt by a wide circle of friends. The portrait is from his last photograph, which was taken twenty-two years ago. •

CHARLES L. STROBEL,
W. H. FINLEY,
W. T. REEVES,
Committee.

THE JOHN CRERAR LIBRARY

AKSEL G. S. JOSEPHSON.

*Read before the Swedish Engineers' Society of Chicago,
Saturday, February 6, 1909.*

Chicago has, as you of course all know, three large free public libraries, namely, The Public Library of the City, The Newberry Library, and The John Crerar Library. The Public Library is general in scope, as behooves the circulating library of a large city, though specializing in a few lines, notably in architecture. The Newberry Library is devoted to "humaniora," that is history, philology and linguistics with literary history, philosophy, and theology; it possesses a large number of rare and valuable books, including some 200 incunabula, and is particularly rich in Americana, being the depository of the Edward E. Ayer collection on American Indians, and in modern linguistics and dialect study, represented by the famous Bonaparte library. The special field of the John Crerar Library is that of the natural, physical, social and medical sciences with their applications. This limitation of the scope was determined by the Board of Directors upon the organization of the library, after a careful study of the library facilities of the city. An agreement between the three libraries not to duplicate, unnecessarily, each others collections was made, and following this, the John Crerar Library actually purchased from the Newberry Library its collection of scientific and technical books, numbering between 8,000 and 9,000 volumes. Through this selection of a special field, this newest of the city's libraries announced from the start its intention to supplement rather than duplicate the work of the older institutions, and the selection of this particular field has been amply justified by results. Opening its doors in April 1897 with a collection of 15,000 volumes, it has now on its shelves considerably over 230,000 and while during the first nine months of its existence it was visited by 18,584 persons who called for 6,995 books and 3,864 numbers of current periodicals, the corresponding figures for the year 1908 were: 130,049 visitors, 108,662 books and 20,980 numbers of periodicals. This recorded use does not, however, represent the total actual use; the use of the books on the open shelves in the reading rooms is not recorded; furthermore, readers are very frequently admitted to the stacks, when they desire to use a large number of books or to consult long files of periodicals; the number of persons thus admitted was in 1897, 359, and in 1908, 2,671. Some figures illustrating the relative strength of the six general groups in which the books of the library are divided for purposes of statistics may interest you. They are taken from the annual report for 1908 and represent the resources of the library on December 31 of that year. The total number of volumes on the shelves of the library

on that day was 232,403.* Of these 15,728 were still awaiting classification, belonging chiefly to the Ely and Gerritsen collections, of which more later; I will add, however, that even these are available through special records and can on request be given out. 31,423 volumes were classed under what we call General works; bibliography, encyclopedias, general periodicals and publications of general societies, and also such subjects as philosophy, history, and geography, which, though not falling within the library's field, must be to some extent represented in any large library. 49,773 volumes come under the head of Social sciences, and to this group belongs also the bulk of the unclassified material. 23,331 volumes are classed under natural sciences, 20,219 under physical sciences, 43,627 under applied sciences; the Department of Medical Sciences, the latest and most important addition to the library, contains 48,302 volumes.* This department has a history of its own. It had its origin in the libraries given to the Chicago Public Library, on its establishment after the great fire, by the Chicago Medical Society, the Medical Press Association and the Homeopathic Relief Association. Afterwards the Medical Library Association of Chicago was formed to develop a medical reference collection, as it was found that the Public Library could not undertake that task. In 1890, after having collected some 1,500 volumes and 2,000 unbound periodicals, this Association asked the Newberry Library to take over its collections and assume the responsibility of establishing a medical reference library. The authorities of the Newberry Library agreed to do this and received then as a gift the collection of the Medical Library Association, and later, upon remunerating the Public Library for its incurred expense, the medical books in its possession, 6,583 volumes and 4,550 pamphlets. To these the Newberry Library added considerably so that by the end of the year its medical department contained more than 17,000 items. Later on, the American Medical Association transferred its library to the medical department of the Newberry Library. The largest gift which the department received was the Senn collection, presented to it in 1894 by Dr. Nicholas Senn; besides a large number of books from the donor's private library, it contained the libraries of Dr. W. Baum of Gottingen and of Dr. E. Du Bois-Reymond of Berlin. When the John Crerar Library was organized and the question of a division of the field of literature between the three large libraries of the city was discussed, it was felt on all sides that medicine logically belonged within its field, but it was not at that time practicable to make the transfer. In 1906, however, the transfer of the Medical Department of the Newberry Library, including the Senn collection, to the possession of the John Crerar Library was made. In 1907 the books were moved to the quarters of the latter library; over 3,000 volumes of modern medical works have since been added

*Unbound pamphlets are not included in this statement.

to the department; from Dr. Senn the department received, in 1906, an important gift of nearly 900 volumes, including many scarce books, and after his death his private library of some 3,500 volumes was presented to it by his heirs.

Another large collection added to the John Crerar Library is the Gerritsen collection, already mentioned. Mr. Gerritsen, a banker and city councilor of Amsterdam, had devoted a large part of his life to collect books on political economy, especially money and banking, finance, and socialism. In 1903 he withdrew from public life, intending to make a journey round the world, and decided to dispose of his library. It was offered to the John Crerar Library and in due time purchased. Soon after, Mr. Gerritsen died. The collection consisted of some 18,000 volumes and 13,000 pamphlets, and included a special collection on the social, political and legal status of woman, formed by Mr. Gerritsen's wife, Dr. Aletta H. Jacobs; a catalogue of the major part of this collection was exhibited at the Paris exposition in 1900 and received a diploma of honor. Aside from the acquisition of these larger libraries and of two or three collections of smaller size, the most important of which is that on American labor conditions, formed by Professor Ely, it has been the policy of the library to build up its various departments systematically and uniformly. It has purchased most of the important publications within its field published since 1896, and a large part of those of more than ordinary significance of the older literature, chiefly books of standard value. This has been the case, for instance, with the subject of most interest to the members of this society, engineering. Here the library can claim the possession of a very good working collection, as has been testified to by its use: the books classified under engineering, under building and under physics which, according to the library's classification, includes electrical engineering, number on December 31, 1908, 19,665 volumes, and of these over 100 per cent, or 20,713 were called for during the year. The proportion of all the books in the library to the recorded total use, was as 2.3 to 1.1 during this same period. In addition to this, 5,200 numbers of current periodicals on engineering, building and physics were called for, representing over 25 per cent of the total recorded use of current periodicals.

The importance of the information found in periodicals and transactions was recognized from the start and special care has always been given to the purchase of this class of publications. The library has now on its shelves considerably over 10,000 serial publications, of which 2,889 are received annually, 526 of these by gift.

The library published in 1902 a list of the periodicals currently received by it, but it is now, of course, much out of date; at that time the library received, by purchase or gift, about 1,600 serials. In this list the titles are repeated in three arrangements, alphabetical, by classes, and by languages; of Swedish periodicals, the library received then 18; at present it has on its shelves, all told, about 30

serials in the Swedish language. These number among them such publications as *Teknisk Tidskrift*, *Nordisk Tidskrift*, the whole series of periodicals called *Svensk Tidskrift*, from 1865 to 1895; also a complete file of the publications of the Academy of Science at Stockholm, *Jernkontorets annaler*, *Hygiea* and *Nordiskt Medicinskt arkiv*.

A list of serial publications in all, or nearly all, the important libraries in Chicago and Evanston was published in 1901 by the Chicago Library Club, and two editions of a supplement to it were issued by the John Crerar Library, the first in 1903, the second in 1906; a new edition of the original list will be undertaken by that library, in the near future. Some data in regard to the number of serials in the libraries of Chicago might interest you. The original list contained the titles of 6,640 serials, of which 3,755 were *currently* received in at least one library; 4,310, or 65 per cent were to be found in only one library; 1,175, or 18 per cent, in two libraries; 580, or 9 per cent in three libraries, and 550, or 8 per cent in four or more libraries; 2,360, or 36 per cent, were in other languages than English. In 1906 the total number of serial publications in Chicago libraries was about 12,000. At present, it is safe to say that this number is at least 15,000. The second edition of the supplement contains the titles of 8,460 serials, of which 3,150 are additions to those given in the original list, while the others were repeated with alterations; these alterations were either made because files had been completed, or because a library which previously did not possess certain serials had secured copies in the meantime. Of the 8,460 serials listed in the second supplement, 5,240, or 62 per cent, were received *currently*; 4,880, or 58 per cent, occurred in one library only, 1,790, or 21 per cent, in two libraries, 810, or 10 per cent, in three libraries, and 980 or 11 per cent, in four or more libraries; 2,810, or 33 per cent, were in other languages than English.

Other bibliographical publications of the library are: A list of books in the Reading Room, in 1900, (now out of print, but a new edition is in preparation); a list of Bibliographies of special subjects, 1902, giving the titles not only of books shelved as bibliographies but also of books on special subjects which contain bibliographical information; a list of books on Industrial Arts, 1903, issued at the request of a local society, though the material in the library at that time was not as well rounded out as it has since become; a list of Encyclopedias and Dictionaries, 1904, the only guide to this sort of literature that is known to me; and finally, a list of books exhibited December 30, 1907, to January 4, 1908, in honor of the American Medical Association and the Bibliographical Society of America, which list included the titles of all the incunabula and of a large part of the sixteenth century books in the Senn collection. The library has now under preparation, a list of books on the History of Science, which is expected to be ready for publication early next year. Special efforts are in the meantime being made to increase

the library's collection on this subject. The purpose of these publications is primarily to give persons living at a distance, or constant users of the library, information as to its contents; in some cases they have been used as guides for the purchase of books, both for public and private libraries. The titles are, except in the Exhibition list, arranged by subjects, the system used being the Decimal classification, and they are repeated under as many heads as is required; the lists have also alphabetical indexes of names and subjects. The lists are printed from electrotypes prepared from the forms from which the cards for the catalogues of the library are printed. These cards, of which a small supply is always kept on hand, are sold at the nominal price of one cent a card, if ordered by serial number or if all cards on a certain subject are wanted, and at two cents for the first card and one cent for additional cards for the same title, if a selection is involved. Through these printed cards it is possible for the library to supply information in regard to its resources in special fields, and to keep such information up to date. I mentioned the list of books in the reading room. These number about 4,000 and are intended to include, besides general books of reference and the most useful bibliographies, the best books, both advanced and popular, on each important subject within the scope of the library, and a selection of other works either specially interesting or much in demand. These books can be consulted without any formality; the books in the stack, of course, will have to be called for on specially provided call slips; readers wishing to consult a large number of books are admitted to the stacks after application to the Reference Librarian. The collection of books on the open shelves in the medical reference room are selected on a somewhat wider plan than those in the general reading room. The library is a reference library and books are not issued for home use; in special cases, however, if a book is needed for use in connection with a certain piece of work it can be loaned for a very short time, unless it is of a kind that is constantly required on the premises. Some other reason than the personal convenience of the would-be borrower must be given. Books can also be lent, on similar conditions, to students out of town, and the library will borrow for its patrons, books from libraries in other cities to be used on its premises.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

REGULAR MEETING, MAY 5, 1909.

A regular meeting (No. 662) of the Society was held Wednesday evening, May 5th. The meeting was called to order at 8:25 p. m. with President Allen in the chair and about 100 members and guests present. The minutes of the meetings of April 7th and 21st were read and approved.

The Secretary reported from the Board of Direction the election into membership of the following:

	<i>Grade.</i>
Edwin A. Howes, Chicago.....	Active
Chas. C. Chappelle, Chicago.....	Active
Frederic S. Sly, Chicago.....	Associate
Thomas W. Orbison, Appleton, Wis.....	Active
James O. Heyworth, Chicago.....	Active
Hiram W. Elliott, Chicago.....	Junior
W. H. Kellogg, Jr., Grand Rapids, Mich.....	Junior
Jos. D. McCord, Milwaukee, Wis.....	Junior
Charles Stewart, Chicago.....	Junior

Also that the following had applied for membership:

Victor Guillemín, Milwaukee, Wis.

Rudolph F. Kelker, Jr., Chicago.

Manley W. Cluxton, Chicago.

Herbert W. Young, Chicago.

Wm. H. Petersen, Chicago.

The following resolution, prepared by a committee consisting of Messrs. Giaver, Brunner, Finley, Davidson and Ritter, was presented by Mr. Giaver, chairman, and read to the Society by the Secretary:

WHEREAS, There is before the General Assembly of the State of Illinois a bill providing for the appointment of a Commission to revise and codify the building laws of the State of Illinois; and

WHEREAS, The object of so revising and codifying the building laws of the State of Illinois is to provide for the safety in construction and sanitary arrangements of public buildings in general; and

WHEREAS, The preamble and resolution now before the General Assembly lays especial stress on the engineering features, structural and sanitary, of our buildings, and the mechanical and electrical features of their equipment, and it is the sense of the Western Society of Engineers that the engineering profession should have a fuller representation on the proposed Commission if the desired result shall be obtained; therefore

BE IT RESOLVED that the Western Society of Engineers recommends that the Commission to be appointed for the above purpose should include one member from the Western Society of Engineers and one member from each of the following national engineering societies: The American Society of Civil Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers; said members to be citizens of the state of Illinois, and the number of members on the Commission to be increased, if necessary, to accomplish the above object.

RESOLVED further that this resolution be spread upon the minutes of the Society, and that a copy of same be sent to the proper officials of each of the national engineering societies, the Secretary of State of Illinois, the Speaker of the House, the President of the Senate, and members of the General Assembly.

The resolution was discussed by Messrs. Giaver and Finley and then put to a vote and adopted.

Prof. L. P. Breckenridge, M.W.S.E., was then introduced who presented his paper, in abstract, on "The Engineering Experiment Station and its Relation to Illinois Industries." A number of interesting lantern-slide views were shown in explanation of the paper.

Discussion followed from President Allen and Messrs. W. F. M. Goss, W. L. Abbott, and James Lyman.

The meeting adjourned about 10:20 p. m., when some refreshments were served.

EXTRA MEETING OF MAY 19, 1909.

An extra meeting of the Society (No. 663), was held Wednesday evening, May 19th. The meeting was called to order at 8:25 p. m. with Vice-President Junkersfeld in the chair and about 70 members and guests present. There was no business to bring before the Society, so Maj. W. V. Judson, of the U. S. Engineers, now of Washington, D. C., was introduced, who presented his paper—"Concrete Steel Caissons; Their Development and use for Breakwaters, Piers and Revetments." The paper was illustrated by a number of stereopticon views. Discussion followed from W. H. Finley, L. K. Sherman, Thomas H. Rees, Admiral Ross, C. McD. Townsend, and Maj. Judson.

In the remarks of Admiral Ross, of the Great Lakes Naval Training Station, near Lake Bluff, Ill., he extended an invitation to the Western Society of Engineers to visit the Naval Station, which invitation was accepted, informally, by the Society.

Mr. O. P. Chamberlain offered a motion of a vote of thanks to Maj. Judson for his valuable and interesting paper.

The meeting adjourned at 10:15 p. m.

EXTRA MEETING, MAY 27, 1909.

A *special* extra meeting (No. 664) was held Thursday evening, May 27th,—a "Ladies Night."

The Treasurer, Mr. A. Reichmann, presided, calling the meeting to order about 8:20 p. m., with about 125 members and guests present.

Mr. Isham Randolph, M.W.S.E., was introduced who gave an entertaining account, with lantern slide illustrations, of his trip last January, to Panama. The speaker was one of a board of engineers, commissioned by President Roosevelt, to accompany Mr. Taft to Panama to look over the plans and work done, and to make a report on the results of their studies and observations.

The meeting adjourned about 9:40 p. m., when refreshments were served.

J. H. WARDER,
Secretary.

JOINT MEETING ELECTRICAL SECTION W. S. E. AND CHICAGO BRANCH A. I. E. E., MAY 28, 1909.

A meeting (No. 43) of the Electrical Section W. S. E. (being No. 665 of the Society) was held jointly with the Chicago Branch, American Institute of Electrical Engineers, on Friday evening, May 28th.

The meeting was called to order about 8:30 p. m. with Mr. W. L. Abbott, Chairman, Chicago Branch A. I. E. E., presiding, and about 190 members and guests in attendance.

The Chairman presented the subject of the evening—"Certain Phases in the Development of the Street Railway Systems of this City," and introduced Mr. B. J. Arnold, Chief of Board of Supervising Engineers. Mr. Arnold explained the composition, duties, and responsibilities of the Board of Supervising Engineers, and the evolution of their work, under the ordinances of the city. He was followed by Mr. H. B. Fleming, who presented a paper describing, somewhat in detail, the technical side of the subject. "Street Rail-

way Carhouse Design and Operation, Carhouse Repairing and Cleaning." The Chairman then introduced Mr. George Weston, another member of the Board of Supervising Engineers, representing the interests of the city of Chicago, who recounted the work of reconstruction of tracks, etc. Other discussion followed from Messrs. Budd, Junkersfeld, Lake, Roper and Arnold.

As Mr. Abbott had to leave early, to go out of the city, Mr. W. B. Jackson succeeded him in the chair.

The meeting adjourned about 10:40 p. m.

J. H. WARDER,
Secretary.

LIBRARY NOTES.

The Library Committee wishes to express thanks for donations to the library. Back numbers of periodicals are desirable for exchange and in completing valuable volumes for our files.

Since the issue of the JOURNAL for April, 1909, we have the pleasure to report the following additions to the library and gifts from donors named:

MISCELLANEOUS GIFTS.

J. H. Warder, Secretary, "From Sail to Steam." Mahan. Cloth. "Elements of Geology," Le Conte. Cloth.

Board of Water Supply, New York, Contracts Nos. 13 to 32, Board of Water Supply, New York, N. Y. 4 pams.

John Wiley & Sons, New York, "Railroad Structures and Estimates," J. W. Orrock. Cloth.

Armour Institute, Chicago, 1909 Bulletin. Pam.

Benezette Williams, M.W.S.E., Chicago, Professional Papers of the Corps of Royal Engineers. Vols. 1-10 incl. Cloth.

Association of Water Engineers, London, Transactions 1908, Vol. XIII. Cloth.

Charles J. Poetsch, M.W.S.E., Milwaukee, Wis. Annual Report of City Engineer of Milwaukee, 1908. Cloth.

Prof. W. D. Pence, M.W.S.E., Madison, Wis. Report of Wisconsin Tax Commission, 1907 and 1909. 2 Vols. Cloth.

Lincoln Bush, M.W.S.E., New York. "Bush Track Construction." Pam.

John F. Icke, M.W.S.E., Madison, Wis. First, Second and Third Annual Reports, City Engineer of Madison, Wis. 3 pams.

Charles B. Ball, Chicago, Proceedings, American Society of Inspectors of Plumbing and Sanitary Engineering. Vol. III, 1908. Pam.

E. E. R. Tratman, M.W.S.E., Chicago, Statistics of Railways in the United States in 1906. Cloth.

Water Supply & Irrigation Paper No. 223. Pam.

Bulletin, International Railway Congress, April 1909. Pam.

City Engineer, Providence, R. I., Annual Report of City Engineer, 1908. Pam.

A. G. Leonard, State Geologist, Bismark, N. D., Second, Third, and Fourth Biennial Reports of the State Geological Survey of North Dakota. 3 pams.

Architectural Record Co., New York, Sweet's Index, 1909. Cloth.

A. P. Low, Ottawa, Can., Report of the Department of Mines, 1908. Pam.

Sanderson & Porter, New York, Hydro-electric Development at Berrien Springs, Mich. Pam.

- Commissioners of Lincoln Park, Chicago, Annual Report for 1908. Pam.
 Wm. H. Scoville, Comm., Hartford, Conn., Reports of Bureau of Labor
 Statistics, State of Connecticut, 1889, 1891, 1892, 1893, 1894,
 1898, 1900, 1905, 1906, 1908. 7 Vols. Cloth. 3 pams.
 Minister of Lands, Forests, and Mines, Toronto, Can., Sixteenth Report of
 the Ontario Bureau of Mines. 1907. Cloth.

GOVERNMENT.

- U. S. Geological Survey, Department of the Interior.
 Professional Paper No. 59.
 Bulletins Nos. 356, 368, 371, 372, 376, 378.
 Water Supply and Irrigation Papers Nos. 223 and 225.
 28 Topographical Maps.
 Production of Monazite and Zircon in 1908.
 Production of Salt and Bromine in 1908.
 Production of Bauxite and Aluminum in 1908.
 Interstate Commerce Commission, Statistics of Railways in U. S. 1907. Cloth.
 Annual Report for 1899. Cloth.
 War Department, Chief of Engineers, Preliminary Report on Inland Water-
 ways Commission. Pam.
 Report of Jamacia Bay Improvement Commission. 2 pams.
 Annual Report of Chief of Engineers, Vol. 5, 1908. Cloth.
 Department of Commerce and Labor, Mortality Statistics, 1907. Cloth.
 Precise Leveling in the U. S. Paper.
 Department of Agriculture, Circular No. 162.
 The White House, Proceedings, Conference of Governors, 1908. Cloth.

MEMBERSHIP

ADDITIONS TO MEMBERSHIP.

	<i>Grade.</i>
Howes, Edwin A., Chicago.....	Active
Chappelle, Charles C., Chicago.....	Active
Sly, Frederic S., Chicago.....	Associate
Orbison, Thomas W., Appleton, Wis.....	Active
Heyworth, James O., Chicago.....	Active
Elliott, Hiram W., Chicago.....	Junior
Kellogg, W. H. Jr., Grand Rapids, Mich.....	Junior
McCord, Joseph D., Milwaukee, Wis.....	Junior
Stewart, Charles, Chicago.....	Junior
Fry, George W., Charlottesville, Va.....	Active
Evans, William G., Chicago.....	Active
Baughman, Charles A., Marshalltown, Iowa.....	Active
Zaremba, Edward, Chicago.....	Active
McCabe, Horace B., Chicago.....	Active
Guillemin, Victor, Milwaukee, Wis.....	Active
Kelker, R. F. Jr., Chicago.....	Active
Young, H. W., Chicago.....	Associate
Petersen, W. H., Chicago.....	Active
Flagg, Samuel B., Pittsburg, Pa.....	Active

WESTERN SOCIETY OF ENGINEERS

SECRETARY'S OFFICE, LIBRARY, READING ROOM AND MEETING ROOMS
1735 Monadnock Block, Chicago.

LIST OF OFFICERS FOR 1909

President.....ANDREWS ALLEN
First Vice-President P. JUNKERSFELD
Second Vice-President.....O. P. CHAMBERLAIN
Third Vice-President.....W. F. M. GOSS
Treasurer....A. REICHMANN

TRUSTEES

W. C. ARMSTRONG.....Term expires January, 1910
L. E. RITTER Term expires January, 1911
G. M. BRILL Term expires January, 1912
B. J. ARNOLD, W. L. ABBOTT, C. F. LOWETH.....Past Presidents.

The above named officers of the Society and three past presidents, constitute its Board of Direction.

Secretary and Librarian

J. H. WARDER

COMMITTEES

On Finance—P. Junkersfeld, A. Reichmann, John Brunner
On Publication—O. P. Chamberlain, C. B. Burdick, Wm. B. Jackson,
A. Bement, Ernest McCullough, E. N. Layfield, M. K. Trumbull, O. J. West.
On Library—W. C. Armstrong, L. J. Hotchkiss, E. N. Lake.
On Amendments—C. F. Loweth, W. L. Abbott, B. J. Arnold,
W. T. Reeves, M. K. Trumbull.
On Membership—L. E. Ritter, C. M. Denise, D. W. Roper.
On Entertainment—G. M. Brill, W. A. Hazard, James Lyman.
On Increase of Membership—S. T. Henry, F. W. Boldenweck,
C. W. Brooks, Arthur Lewis, M. W. Priseler.

THE ELECTRICAL SECTION

Wm. B. Jackson, Chairman, P. B. Woodworth, Vice-Chairman, for 1909.
K. B. MILLER.....1 year
E. N. LAKE.....2 years
W. L. ABBOTT.....3 years

Members of Executive Committee.

MEETINGS

Regular Meeting—1st Wednesday evening of each month except January
July and August.

Extra Meeting—Generally the 3rd Wednesday evening of each month except
July and August.

Electrical Section—Wm. B. Jackson, Chairman, generally the 2d Friday of
the month, October to May, inclusive.

Board of Direction—The Tuesday preceding the 1st Wednesday of each month.

NOTICE

From the dues of each member, \$2.00 is set aside as a subscription to the JOURNAL.

Journal of the Western Society of Engineers.

VOL. XIV.

AUGUST, 1909.

NO. 4.

DERRICK CARS AND BRIDGE ERECTION.

WITH SOME TESTS OF IRON PULLEY BLOCKS.

J. H. PRIOR, M.W.S.E.

Presented March 3, 1909.

The files of the Bridge & Building Department of the C. M. & St. P. Ry. contain some records of tests on blocks, as well as some designs of derrick cars and travelers, made under the direction of Mr. C. F. Loweth, Past President of this Society, which it is thought may be of interest to the members.

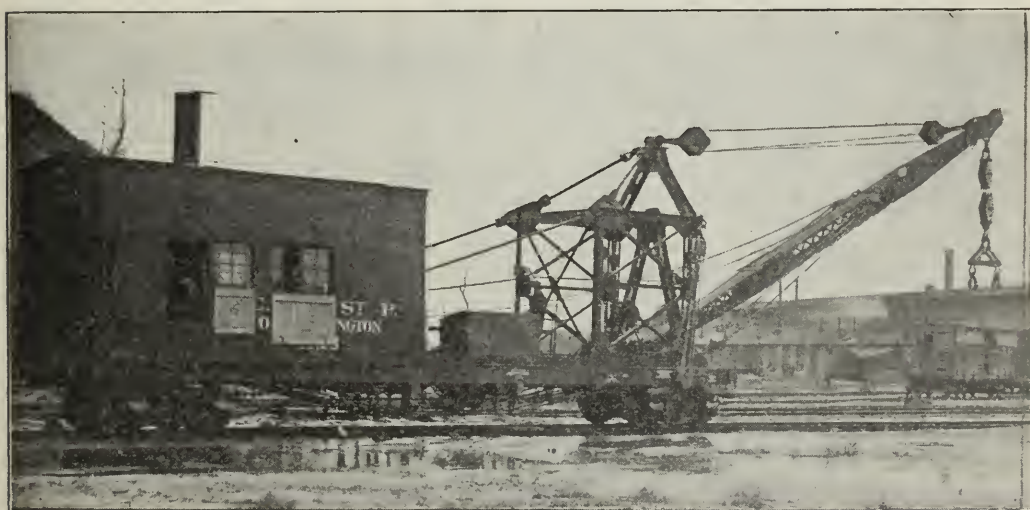


FIG. 2.

DESIGN OF 30 TON DERRICK CAR.

In General. Most of the features of the car, designed by W. F. Rech, are shown in Fig. 1, which shows a 15 ft. 3 in. mast, a 30 ft. boom, some $2\frac{1}{4}$ in. by $2\frac{1}{4}$ in. bars for the backstays, together with the engine and rigging mounted on a 50 ft. flat car of heavy construction.

The principal requirements of a derrick car are:

- (1) Length of boom reach, with necessary stability of the car.
- (2) Strength of parts, with the required lightness for handling.

The number of uses to which a derrick car can be put are almost in proportion to its length of boom.

The longer the boom and the greater its capacity, the greater must be the longitudinal and lateral stability of the car. The longitudinal stability (parallel with the track) is comparatively easily obtained by increasing the length of the car, in this case to 50 ft., and by adding the counter-weight required, to the weight of the engine and rigging already in place. The lateral stability is, however, a difficult matter to provide and is a more doubtful quantity than any other feature of the car: this is due mostly to the fact that the width of base of the car available against overturning is limited to the distance C. to C. of rails, unless outriggers or guys are used. The lateral overturning moment of the load is measured by the product of the load into its distance from the nearest rail, and this overturning is resisted by a moment which is the product of the weight of the car into one-half the distance between the rails.

As this half distance between the rails, or the lever-arm of lateral moment of resistance, is only about 30 inches, it is apparent that the capacity of the car for lifts at any distance from the center line of track is limited. The exact figures are given in the table, Fig. 1.

To reduce the stresses in the boom tackle and its consequent weight, it is desirable to make the height of the tower as great as possible, but the permissible height of the tower is limited by the clear head room in through truss bridges and under telegraph wires, during transit and also when the car is at work.

In the design shown, the top of the tower is 21 ft. 3 in. above top of rail, and it can be seen that the design of the connection at the top of the tower makes practically all of this height effective.

The upper part of the tower consists of an "A" frame, shown in Fig. 2, which can be removed when the car is in transit, thus bringing the total height of the car well within the overhead clearances of any railroad.

The square tower is fully rigged so that when the "A" frame is removed the car can be used for all purposes, but, as the stresses in the top tackle are increased, the capacity of the car is reduced.

The shortest boom is made of two 15 ft. sections; additional intermediate sections of 20 ft. and 35 ft. are provided, making lengths of boom of 30 ft., 50 ft., 65 ft., or 85 ft. available.

When heavy loads are being lifted, there is a provision for the insertion of a tight fitting hard wood block between the body bolster of the car and the side frame of the truck. This permits part of the load to be transmitted directly from the car body bolster to the truck side frame and relieves the side bearings and springs of whatever load passes through the hard wood block.

Fig. 1 shows the arrangement of lines, also of the clutches, brakes and throttle under the control of the engineer. These fea-



Fig. 4.

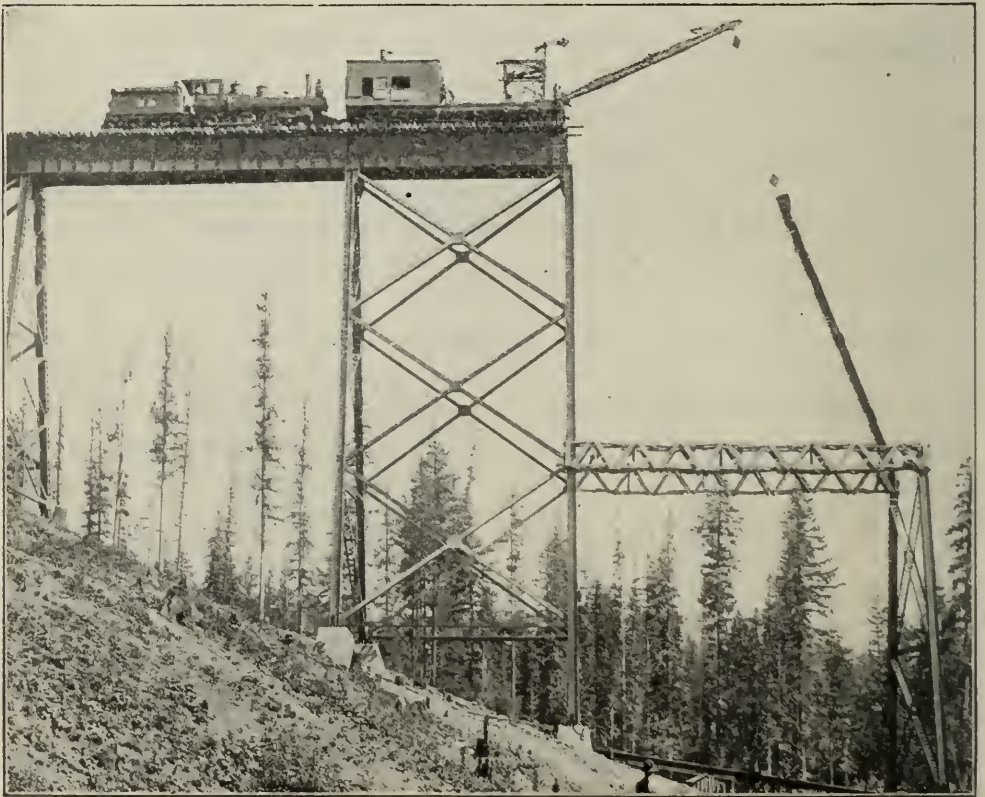


Fig. 5.

tures are shown in diagram only and the cut does not represent the actual construction of the engine.

All winch heads and drums shown are also provided with a ratchet and pawl, not shown in the diagram.

This diagram shows a 30 H.P. engine, of a type extensively used in bridge erection. The chief characteristic of this type (which is common to the different makes) is that all shafts, together with all gear wheels attached to same, are caused to revolve whenever steam is admitted to the cylinder. The drums run loose upon their shafts and can be made to revolve with the shafts, upon which they



FIG. 6.

are carried, by means of friction clutches. When the friction clutch is disengaged, the drum can be held without motion by means of the brake or the ratchet and pawl, the shaft, in the meantime revolving for the purpose of handling other lines.

The winch heads are also loose upon their shafts, but may be fixed to the shafts by the jaw clutches shown, or, when the jaw clutches are disengaged, the winch heads may be held in one position by means of ratchets at their ends and pawls connected to the frame of the engine. When the winch head is held against motion by the pawl, it may be used for fastening the line or holding the load, although the shaft upon which it is carried may be revolving while the engine is handling other lines.

With 110 lb. of steam pressure, the engine can exert a pull of about 8,000 lb. on a line fastened to the drum. As this 8,000 lb. is exerted at a radius of eight inches from the center of the shaft, a considerably greater pull can be exerted by the winch head, which has a somewhat smaller radius.

As shown in Fig. 1, each swinging line and runner line after passing from the front of the car is given a number of wraps around the winch head and then passes into the hands of the winch head man. The pull, which the winch head exerts upon the line, depends upon the number of wraps which the line makes around the winch head, and also upon the pull exerted by the winch head man upon the end of the line. A very light pull, with only a few wraps around the winch head, permits the winch head to slip and revolve within the line which is wrapped around it; a greater pull and more wraps causes the winch head to grip the line with a force which can be increased up to the breaking strength of the line. The boom line and the load line are fastened to the drum, but before commencing operations, it is usual to take a few wraps around the drum, in order to reduce the stress where the line is fastened to the drum.

On this engine, one engineer controls the throttle, in addition to operating the two friction drums. One winch head man operates the two swinging lines and a second winch head man operates the runner line when it is in use. This makes a total of three men in the cab, the engineer doing his own firing.

The car can propel itself with its own power in either direction by means of a chain wheel, which carries a $1\frac{1}{8}$ in. chain which passes around and drives a sprocket wheel keyed to the forward axle of the rear truck. The chain wheel is driven as follows:

A gear wheel is placed on each end of the front shaft, Fig. 1. The gear wheel at one end of the shaft is connected by a train of gears with the chain wheel, so as to make it revolve in the direction which the engine is running and the gear wheel at the other end of the shaft is connected by a similar train of gears so as to make the chain wheel revolve in the reverse direction. The gears at the ends of the shaft run loose and can each be thrown into service (the other gear running idle) by means of a jaw clutch, feathered to the middle of the shaft. This arrangement permits the car to be propelled in either direction by a non-reversible engine.

Some uses of the 30 ton car. On a structure such as the Peedee Viaduct, shown in Fig. 3, where the material must be brought out on the track and where falsework cannot be economically used, a boom of 80 ft. reach would be required to place a single bent ahead of the portion of the structure already erected. The same result can be accomplished with a shorter boom, though not so conveniently, by outhauling the member beyond the reach of the boom, as is shown in Figs. 4, 5 and 6. These illustrations show the progressive stages in the erection of a 75 ft. viaduct span ahead of the derrick car without the use of falsework. The last view, Fig. 6,

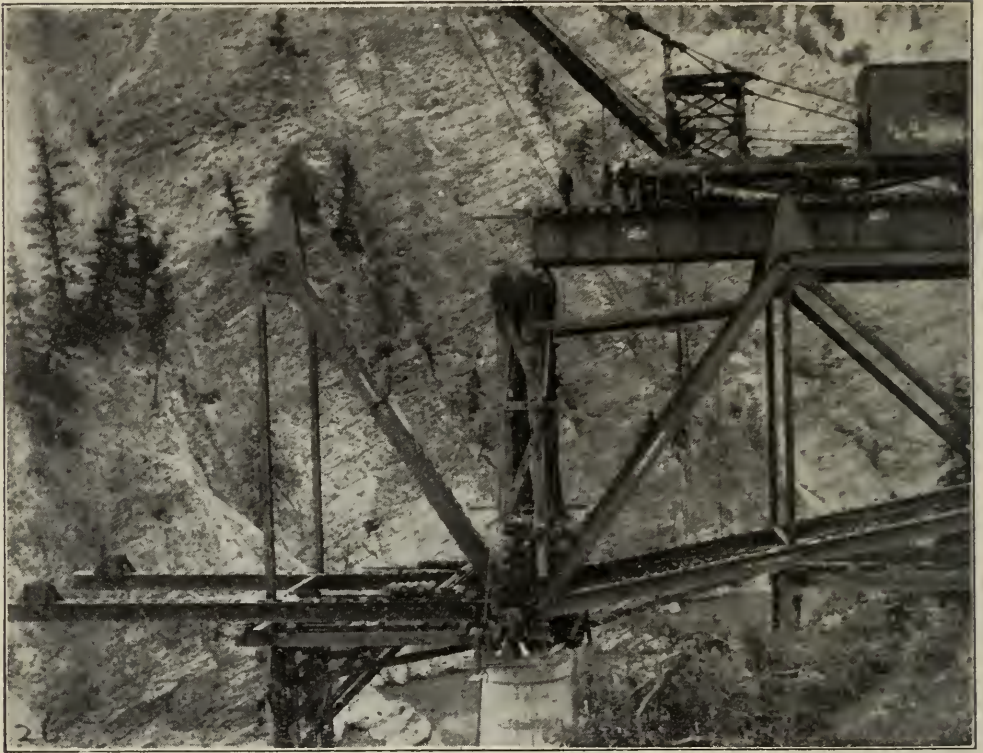


FIG. 8.

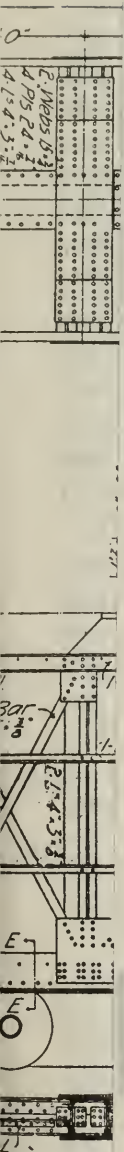


Fig. 9.

42.5

0

6'4" 3/4" 6'



shows the 75 ft. track girder being placed in position. At the conclusion of this operation the structure is self-supporting and, as soon as the laterals are placed, the track ties and rails can be laid, which will permit the derrick car to move forward 75 ft. and complete the erection of the 50 ft. tower.

At the third crossing of the Missoula River, shown in outline in Fig. 7, there is a 240 ft. span crossing a torrential mountain stream. The bottom of this stream is bare rock and does not afford the anchorage which falsework would require to resist the force of the current. This made it necessary to design the span so it could be erected as a cantilever; the joints being arranged as shown in the figure, the structure would be rendered self-supporting, with the completion of each connection.

Working from the end of the structure (to the right on Fig. 7), the 70 ft. girders were first placed. Figure 8 shows the first member for the 240 ft. span being placed by the derrick car standing at the end of the completed 120 ft. span. Figure 9 shows the 240 ft. span self-supporting as a cantilever, with derrick car near the end; this illustration also shows the guying of the car on the boom. Figure 10 shows the last members in the 240 ft. span being placed.

The two bents of falsework in Fig. 10 were placed to make the handling of the last members of this span more convenient. The water level shown in the photograph is considerably lower than the level which was expected at the time the erection was planned. In Fig. 11 is shown one of the 80 ft. spans being placed and the structure practically completed.

The spans between towers of Cow Creek Viaduct, Fig. 12, are 61 ft. 8 in. In order to place a tower bent ahead of the completed portion of the structure without outhauling, a boom of 66 ft. 8 in. reach would be required. These bents, however, were placed with the 65 ft. boom available, the small amount of outhauling being done with hand lines.

As shown in Fig. 13, the material for this viaduct was brought out to the point where it was required on a small tramway running on the ground along the center line of viaduct, the material being delivered to the tramway from the track above by a wrecking crane, which happened to be available. This method differs from that used at Peedee Viaduct, Fig. 4, where all material was delivered above and carried to its position suspended from the boom of the derrick car. This method of bringing out the material on a tramway was made possible by the level bottom of the valley which the viaduct crosses.

This illustration also shows the lower story of the tower being erected by a mule traveler, running on a wide gauge track and moving continuously away from the portion of the structure erected. The details of this traveler are shown in Fig. 14. This arrangement, which kept the derrick car continuously supplied with material without moving from its position at the end of the completed portion,



Fig. 10.

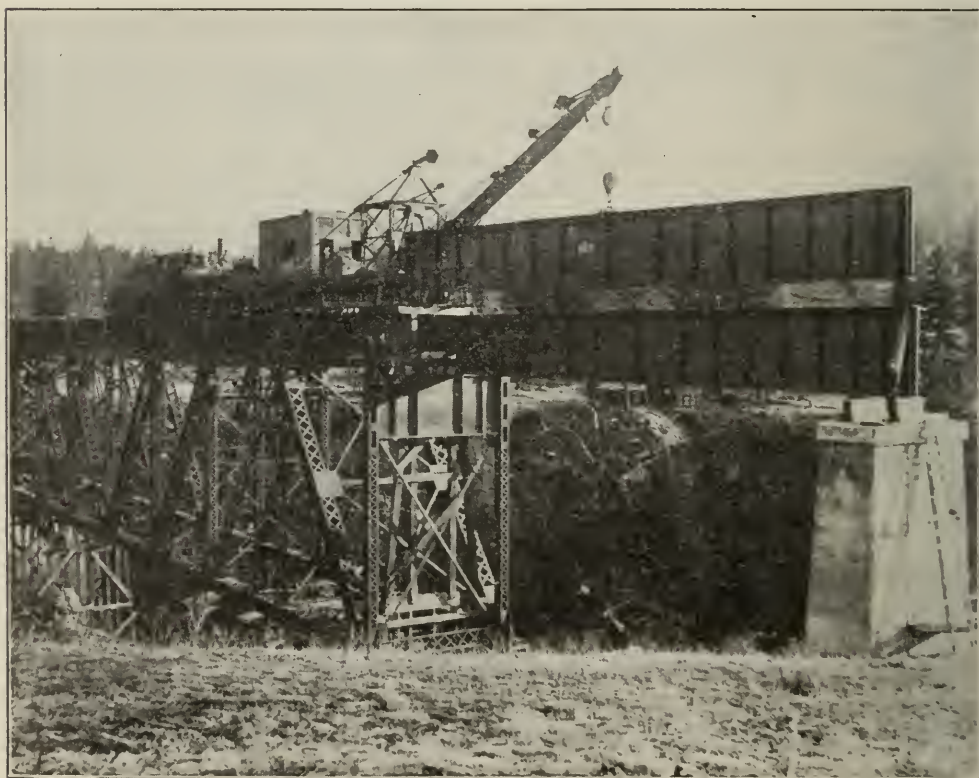


Fig. 11.

greatly increased the erection speed. This viaduct, as shown in Fig. 12, consists of 27 spans, supported by 12 towers, and was erected by the company forces in eighteen consecutive days.

DESIGN OF 50 TON DERRICK CAR.

In General. Figure 15 shows the general features of the 50 ton derrick car, designed by W. E. Pruett. The principal requirements of design and the difficulties encountered in satisfying them, as given in the description of the 30 ton car, are equally true as applied to the 50 ton car; but, in this case, the essentials of reach, stability, etc., were provided in a somewhat different manner.

The longitudinal stability of the car was increased by the addition of 25 tons of counter-weight; and its lateral stability by the use of outriggers.

Figure 15 shows this car to consist of a steel superstructure mounted on a steel flat car. The "A" frame, which performs the work of a mast, is riveted to two transverse channels which are fitted to the two circular castings "M," which, in turn, rest on the plates which are riveted to the sides of the car. The channels form a box, into which the I beam outrigger telescopes when not in use and from which it can be withdrawn, when required, to either side of the car, depending upon the point from which the load is to be lifted. The outer end of the outrigger rests on blocking or a jack, bearing against the ground.

To reduce the stress in the boom tackle, the "A" frame is made as high as possible, being as shown, 21 ft. $\frac{3}{4}$ in. over all above the top of rail. This height is within available clear headroom, but can be materially reduced by revolving the "A" frame backwards around the casting "M" (as shown in dotted lines) when the car is in transit.

At the top of the "A" frame is a forging revolving on its horizontal axis and having bearings for its ends in the "A" frame and back stays. A vertical pin passes through this forging. To this vertical pin are attached two short eye bars, which are also attached to the lower block of the top tackle. The backstays, as mentioned, are also connected to this forging, which is about as central a connection as can be obtained in a derrick car.

The boom is in sections and has a maximum length of 80 ft. when assembled. By the removal and substitution of intermediate sections, this length can be reduced to 65 ft., 57 ft. or 42 ft. The thrust of the boom at the bottom is transmitted by a casting terminating in a spherical surface, to a bronze bushed socket forming a ball and socket joint. The 16 ft. bars shown at the end of the boom tackle are necessary to keep same clear of the boom when using long booms at high elevation. The capacities of the boom in various positions are shown in the table, in the engraving Fig. 16. In spite of instructions, greater loads than these have often been lifted in service.

In Fig. 16 is shown the arrangement of lines on the car, also a diagram of the clutches, brakes, etc., but not the actual construction of the car.

The engine and propelling device on this car are of the same type as described under the 30 ton car and are operated in a similar manner, except that the engine is 50 H. P.

This car is equipped with a large locomotive air compressor. With a boiler pressure of 110 lb., this compressor, with the assistance of



Fig. 13.

two storage tanks located underneath the car floor, will supply sufficient air at 100 lb. pressure for the operation of five riveting hammers.

This compressor also furnishes the air for operation of the car air brakes; the presence of an air brake on the car puts the movement of the car as thoroughly under the control of the engineer as it is when the car is handled by a locomotive, and this has proven a valuable safeguard when moving the car towards the end of the track on the completed portions of high structures, often on a falling grade.

The car cab has a rolling lift front door and a folding side door,

which affords ample view for the engineer and wide openings for exit in case of accident.

The two cars have been employed for over a year, often for duties beyond their rated capacities, and have given satisfaction to the field forces of the department.

The Blacktail Creek Viaduct, shown in Fig. 17, has intermediate spans of 65 ft. Figure 18 shows a tower bent being placed with the 80 ft. boom; the great length of this boom making it possible to do all this work without outhauling

TRAVELER FOR VIADUCTS.

In General. For structures like Tekoa Viaduct, where it was necessary to erect the viaduct on a new line before the track had arrived at that point, and for high structures like Clear Creek Viaduct, where erection had to be hurried to completion before an approach-



Fig. 14.

ing winter in a country noted for heavy snow falls, it was necessary to design an erection machine with a capacity for the continuous and economical employment of a larger working force than would be possible with the derrick cars; the increase in working force to result in proportional increase in tonnage erected per day.

Such a device is the traveler, designed by H. C. Lotholz, shown in general plan, Fig. 19, and with a diagram of lines, in Fig. 20.

It was the intention to use this traveler at three other viaducts and

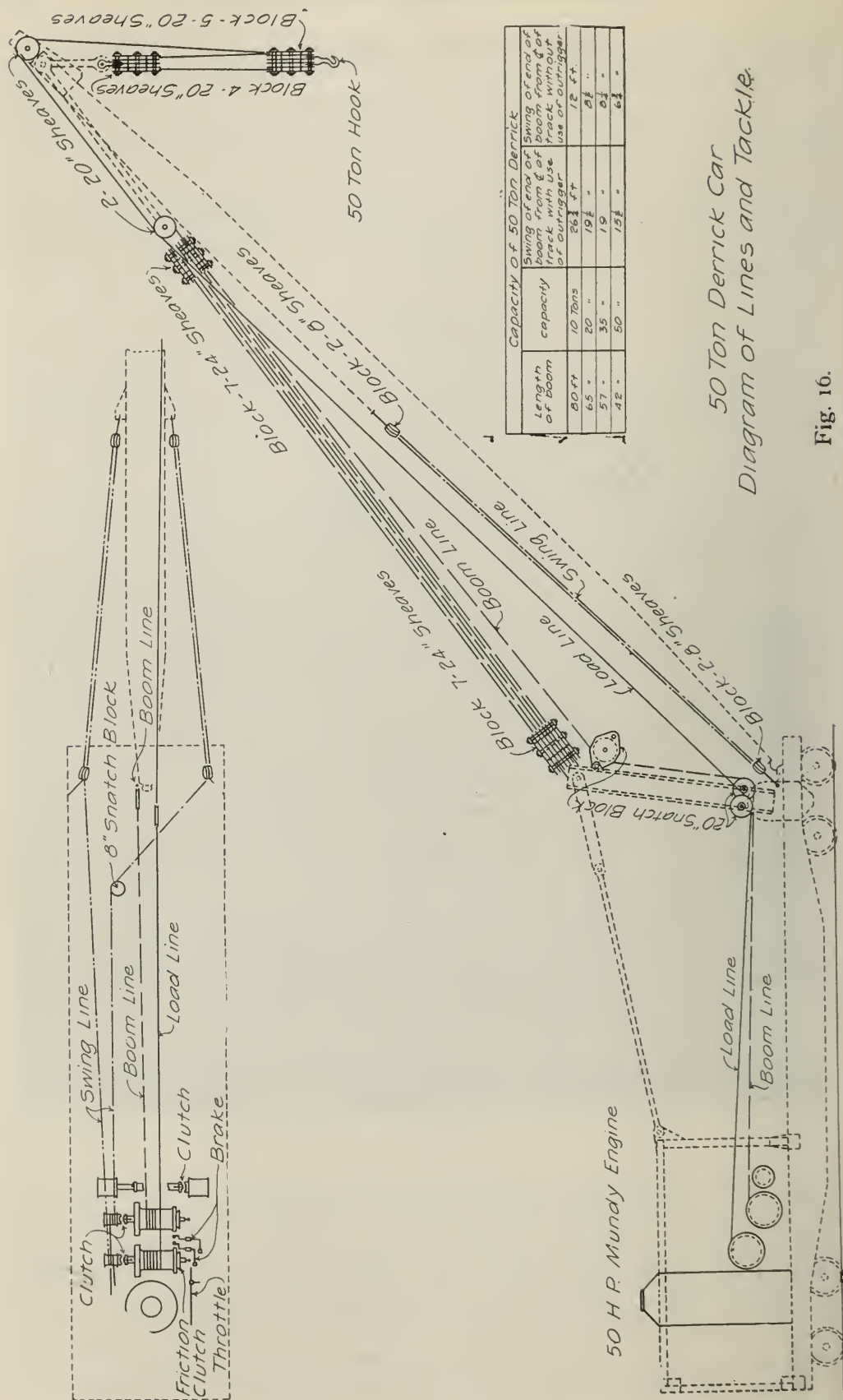


Fig. 16.

so further distribute its cost, but this was prevented by some delay in the completion of a heavy rock cut, where the traveler was to be erected, and by other circumstances beyond the department's control.

The illustrations of this machine (Figs. 19 and 20) show a combination structure of wood and iron, which spans the track, thereby permitting material to be brought to the traveler on flat cars as far as L-6, Fig. 19, and which also permits the passage of trains through the traveler immediately after completion of the structure.

This traveler has a cantilever arm of 75 ft. and two 60 ft. wooden booms, making a total reach of about 120 ft. As shown on Fig. 21, this reach makes it possible to erect an entire tower in advance

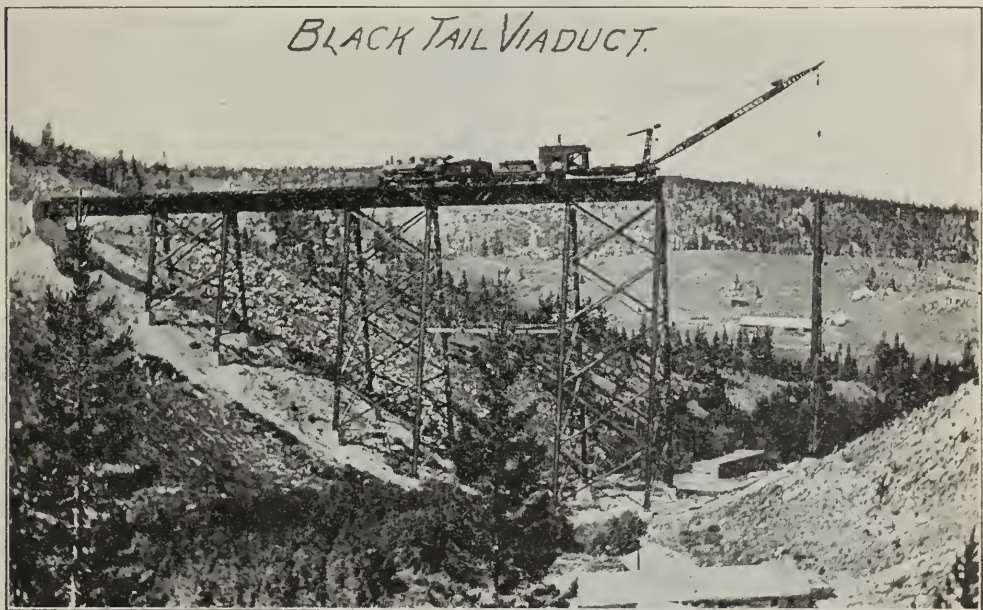


Fig. 18.

of the completed portion of the structure, the tower being stable in itself without the use of temporary braces, as shown in Figs. 4, 5 and 6.

The cantilever arm is equipped with four trolleys, each of 15 tons capacity. Each trolley is composed of a steel carriage on rollers, from which are suspended 2 four-sheave blocks, rove up with nine parts of $1\frac{1}{2}$ in. rope.

A hook of 10 tons capacity was hung from each boom and 30 tons of rail for counter-weight were placed at the rear end of the traveler. Additional anchorage was provided by anchoring the traveler to the girder with hooks. The traveler was also anchored sideways by means of three $\frac{5}{8}$ in. hoisting cable guys, on each side, attached to top of the traveler. The engines are of the same general type as described under the 30 ton derrick car except that the front shaft is omitted and the H. P. is somewhat less.

The following is a rough description of the operation of the traveler and as both sides of the traveler are alike, only one side will be described.

First. The 10 ton hook at the end of the boom is suspended from a four-part tackle of $\frac{5}{8}$ in. hoisting cable, the fall line of which leads through the idler sheave at the top of the boom, thence through a snatch block at the foot of the mast and thence to

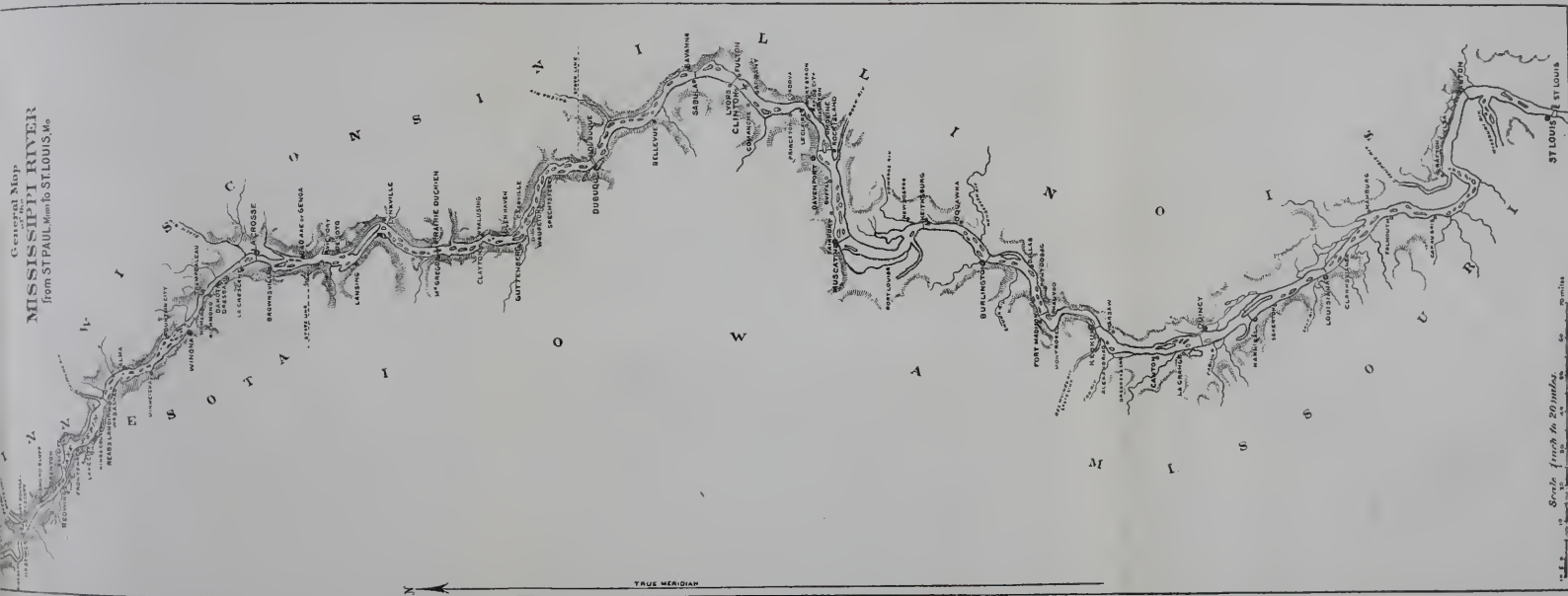


Fig. 23.

the lower drum of the hoisting engine, which is operated by the engineer.

Second. The boom is raised or lowered by a seven-part tackle of $\frac{5}{8}$ in. hoisting cable, the fall line of which leads through a snatch block at the foot of the mast and thence back to the upper drum on engine, which is also operated by the engineer.

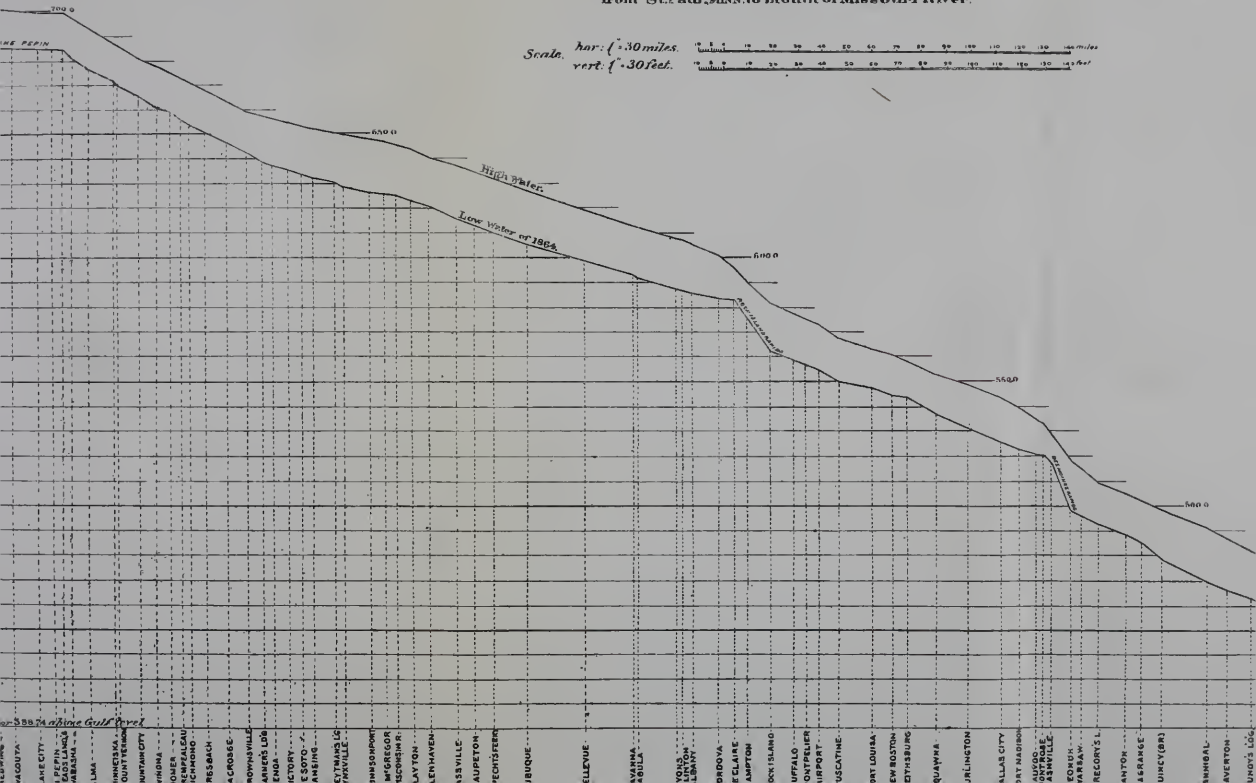
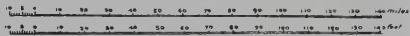
Third. The boom is swung laterally by one five-part tackle (on each side) of $1\frac{1}{2}$ in. manila rope, the fall line of which is led



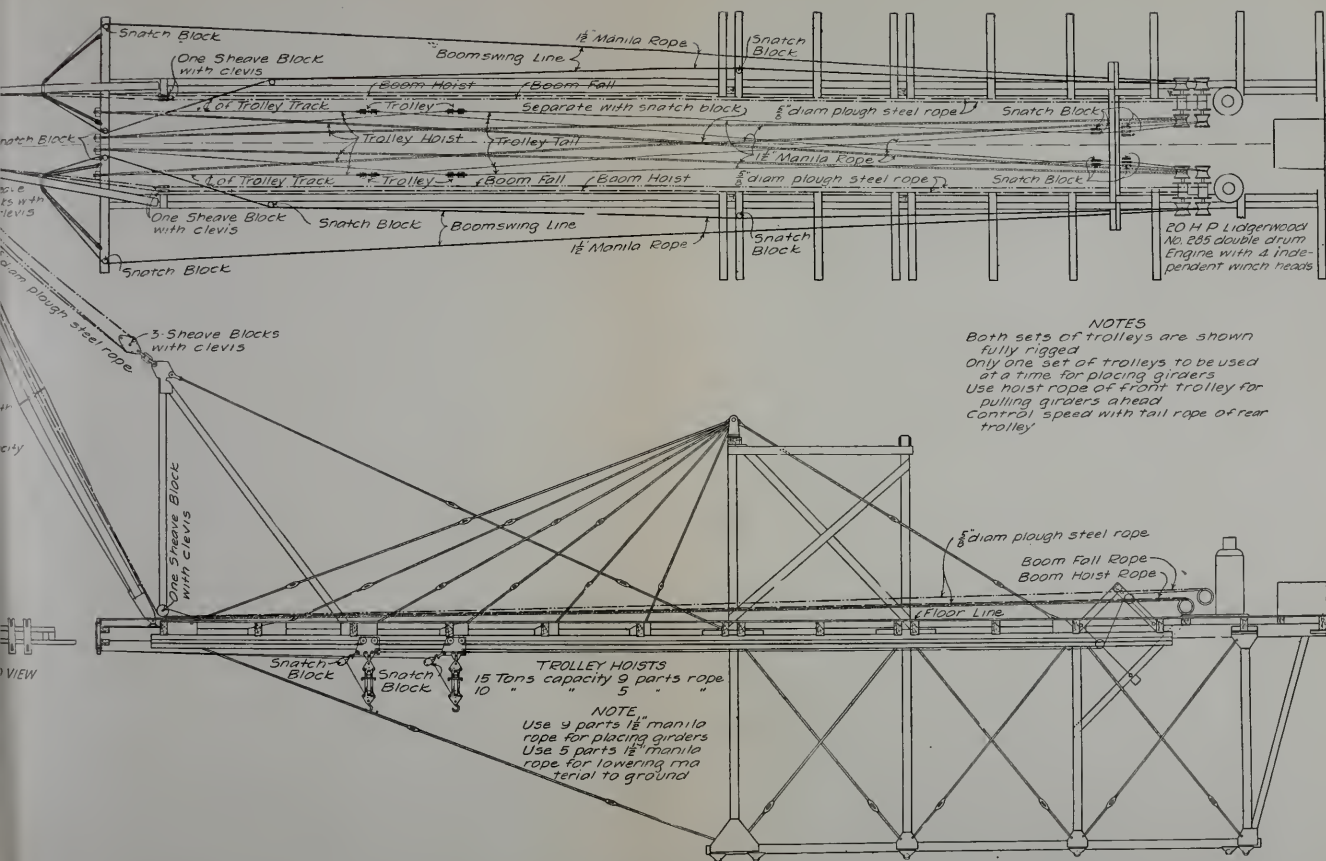
70
7
0.5
60
50
500
150
410

from St. Paul, MINN. to mouth of Missouri River

vert: 1" = 30 feet.







NOTES
Both sets of trolleys are shown fully rigged
Only one set of trolleys to be used at a time for placing girders
Use hoist rope of front trolley for pulling girders ahead
Control speed with tail rope of rear trolley

Diagram of Lines and Tackle for Traveler

om
on
ad

re-
es
ti-
ch
ad
ch
or

e,
ey
ch

y,
r.
g.
ch
ne
ed
ll

through a series of snatch blocks, which prevents the lines from fouling other parts of the traveler, to the outside winch head on hoisting engine. Both of these lines are operated by one winch head man.

Fourth. Each of the 15 ton trolley hooks is supported by a nine-part tackle of $1\frac{1}{2}$ in. manila rope, the fall line of which passes through a snatch block of two idlers at the forward end of cantilever arm and thence back through a number of deck sheaves, which keep the lines from fouling other parts, to the inside winch head of engine. As there are two trolleys, one fall line leads to each inside winch head on the engine. This fall line is also used for



Fig. 24.

traversing the trolley, there being sufficient tension in the fall line, when holding the load, to move the trolley forward, the trolley being also under the control of the trolley tail line. One winch head man is required to operate each trolley tail line.

Fifth. The trolley tail line leads from its fastening to the trolley, through two snatch blocks to a cavel on the deck of the traveler. This arrangement is slightly different from that shown in Fig. 20. In order to keep the trolley under control when it is being hauled forward by means of its own fall line, the tail line which is snubbed around the cavel, as just mentioned, is paid out at the required speed from the cavel. When the trolley is being hauled towards the rear of the traveler for another load, the trolley fall

line and the trolley tail line are interchanged from the position just described, the trolley tail line being wrapped around the winch head, as shown in Fig. 20, and used to haul the trolley back, the trolley fall line being snubbed around the cavel and paid out at the required speed. The entire attention of one man is required for each trolley tail line.

Sixth. In addition to the lines shown in Fig. 20, there are two runner lines (shown on Fig. 21 and marked No. 1 and No. 2), each

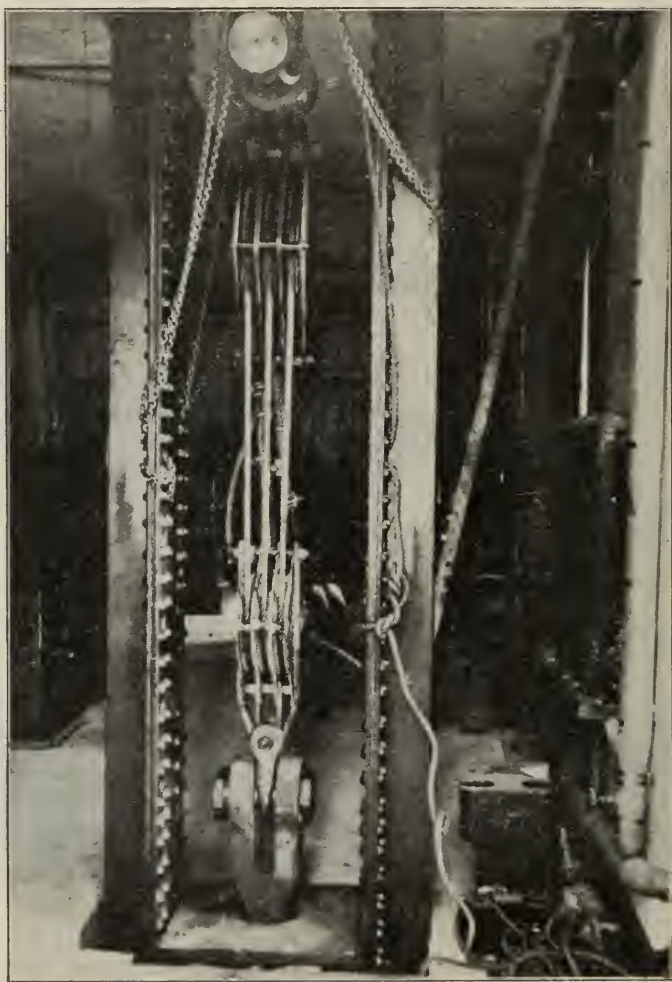


Fig. 25.

of which passes from the load to a snatch block fastened to a stump and leads from the snatch block over the end of the traveler to the outside winch head of engine, on which they are operated simultaneously with the swinging lines. These lines are operated by one of the regular men on the traveler.

Six men have been enumerated in handling lines on one side of the traveler, twelve men being required for both sides. Two of these men are usually available for handling signals, as they are not continuously employed with their lines. A third signal

man, with the assistance mentioned above, transmits all signals. This gives a total of thirteen men on top of the traveler; thirty-seven additional men were required to fill the crew for this work.

Figure 21 shows all lines, in operation, in the erection of the 195 ft. tower of Clear Creek Viaduct. The two booms are placing two columns with boom tackles No. 1 and No. 2; trolleys No. 3 and No. 4 are simultaneously placing two other columns for the same tower; runner lines No. 1 and No. 2 are in service ready to outhaul these columns to their exact location; trolleys No. 1 and No. 2 are lowering to the ground two loads of sway bracing, which will afterwards be picked up and placed in position by the runner lines No. 1 and No. 2, at present running to the stump and being used for outhauling. This illustration also shows a carload of columns which have been run part way through the traveler, which will be lifted from the car by the trolleys and lowered to the ground.

As shown, the traveler is employed to its maximum capacity and working fifty men. The viaduct, which is 210 ft. from base of rail to ground, partly on a 10 degree curve, was erected in 28 working days, by the forces of the Bridge & Building Department under the direction of F. J. Herlihy.

Figure 22 shows Tekoa viaduct, on a new line, which, as mentioned, was erected before the tracks reached its location. The material for this viaduct was delivered to the foot of the inclined tramway, shown in Fig. 23, on which it was hauled up the hillside on a 25% grade by means of hoisting engine and cable rove into a six-part tackle.

Figure 24 shows the traveler on the Tekoa viaduct when the tower and span have been erected, and the long ties are being brought forward from the rear of the traveler preparatory to moving the traveler forward for the erection of the next span.

TESTS OF IRON PULLEY BLOCKS.

The tests of blocks which were made in the testing laboratory of the University of Wisconsin in 1908, by M. C. Withey are summarized as follows:

Block No. 1, Fig. 26	Wt. 277lb.	Breaking Load 148,000lb.
Block No. 2, Sim.to Fig. 2	Wt. 275lb.	Breaking Load 151,000lb.
Block No. 3, Fig. 29	Wt. 225lb.	Breaking Load 86,500lb.
Block No. 4, Fig. 31	Wt. 358lb.	Breaking Load 255,000lb.
Block No. 5, Fig. 33	Wt. 350lb.	Breaking Load 258,000lb.
Milwaukee Block, Fig. 36	..Wt. 720lb.	Not Broken.

Part of the weight of the Milwaukee block was due to the use of 21 in. sheaves to reduce the bending stress in the rope.

The blocks tested were furnished by the manufacturers for that purpose.

General Description of Tests. The testing machine used was a vertical hydraulic machine of 400,000 lb. capacity. The blocks to

be tested were pulled against a triple block, Fig. 36, made at the "Milwaukee Shops," hereinafter referred to as the Milwaukee block, and was designed in the office of Mr. C. F. Loweth.

Both blocks were rove together with $\frac{7}{8}$ in. hoisting cable, the ends of the cable being fastened to the tail bolts of the upper and lower blocks respectively, by means of three clips at each tail bolt, as shown in Fig. 25.

The tension heads of the machine consisted of clevises with pins of large diameter; these pins passed through the clevises of the blocks to be tested. The load was applied gradually and continued until a cracking sound was heard or some indication of failure was seen or suspected. Then the load was released and the block was carefully examined for signs of failure. After several repetitions, the load was continued until the failure was complete. The Milwaukee block was in the upper head of the machine and in all cases the lower block failed, while the upper block remained practically intact.

In these tests, the words above and below refer to the block in the position shown in the testing machine, the clevis being at the lower end in all cases. In making photographs of blocks—No. 1, Fig. 26; No. 2, Fig. 28 and No. 3, Fig. 30—it was necessary to invert the blocks from the position in which they were tested.

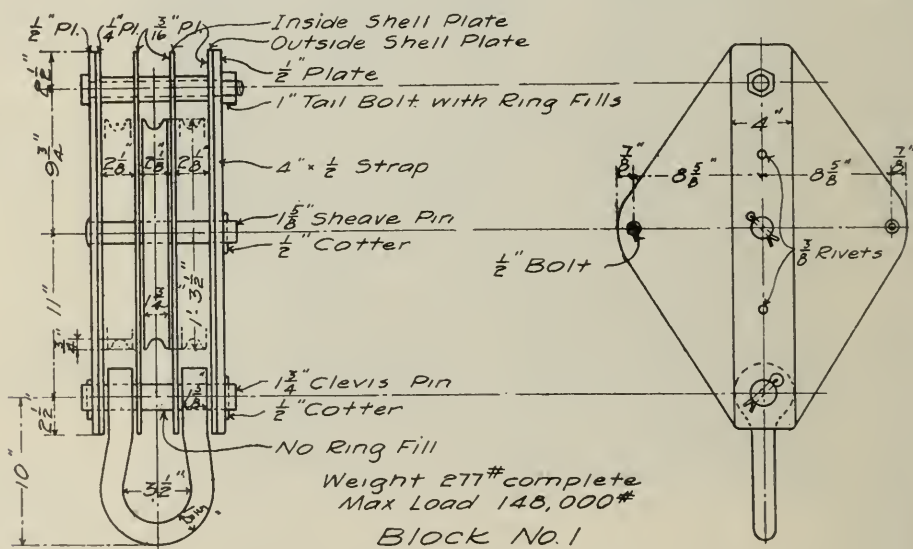


Fig. 26.

BLOCK NO. 1.

Weight of block complete, 277 lb. Maximum load, 148,000 lb.

Test of Block No. 1. Details of this block are shown in Fig. 26; appearance after failure, in Fig. 27. End of cable was fastened at outside segment of tail bolt. At load of 129,000 lb., inside shell plate crushed and pin holes in outside strap at sheave pin elongated.

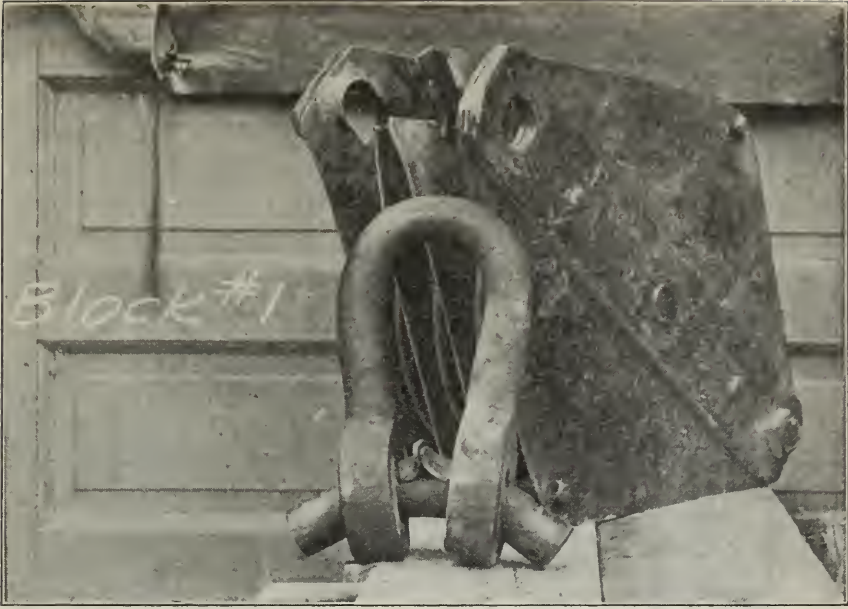


Fig. 27

Description of Failure. Holes in inside shell plates began to elongate, allowing clevis pin to bend; pin kept bending until inside shell plates tore through; this allowed the clevis pin to pull out entirely from the side plates. Clevis was split on one side half way through. All sheaves revolved after test.

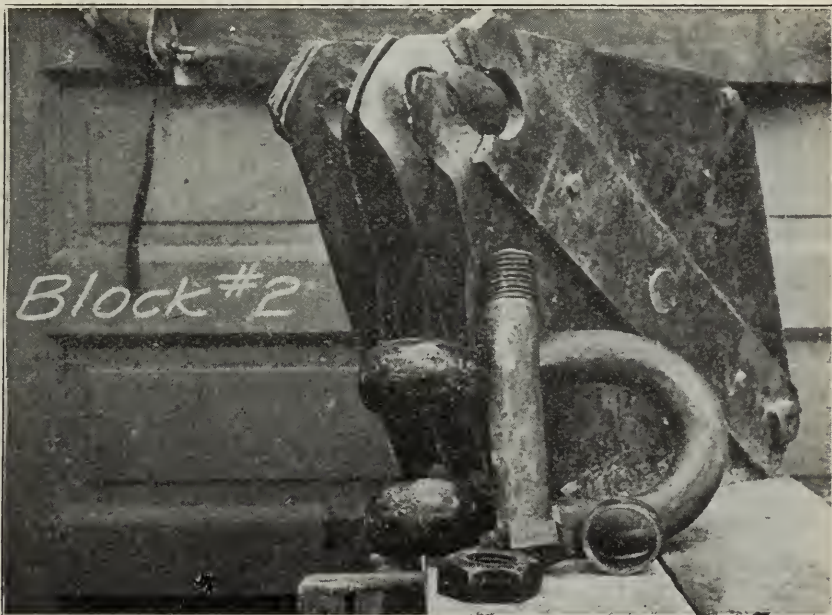


Fig. 28.

BLOCK No. 2.

Weight of block complete, 275 lb. Maximum load, 151,000 lb.

Test of Block No. 2. Dimensions same as for block No. 1, ex-

cept that inside shell plates are $\frac{1}{4}$ in. thick and outside shell plate are 3-16 in. thick; appearance after failure, shown in Fig. 28. End of cable was fastened at center segment of tail bolt.

Description of Failure. Failed at 151,000 lb. Outside shell plate and strap tore out below clevis pin on one side. Inside shell plates buckled and split. Clevis pin bowed $\frac{1}{8}$ in.

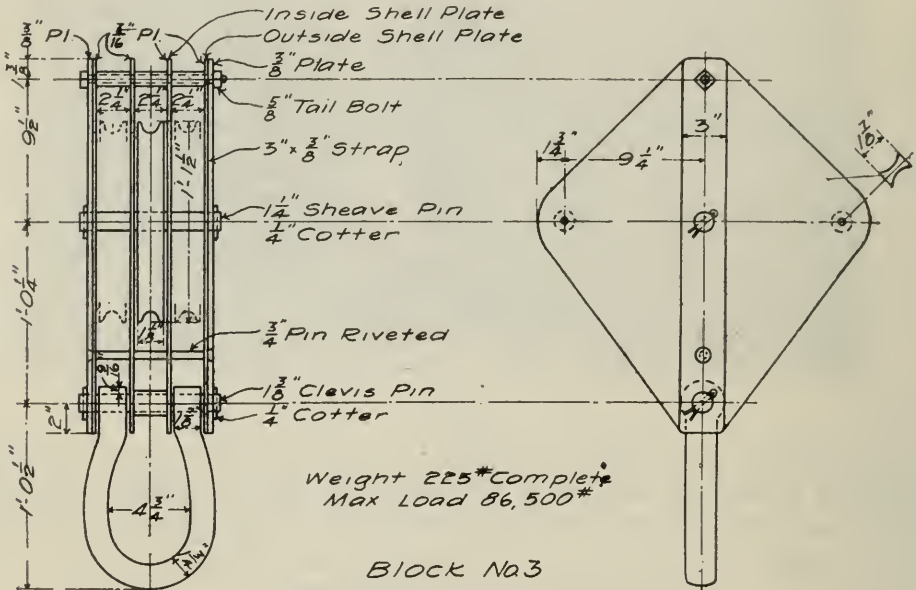


Fig. 29.



Fig. 30.

BLOCK No. 3.

Weight of block complete, 225 lb. Maximum load, 86,500 lb.

Test of Block No. 3. End of cable was fastened at center segment of tail bolt. Details of block shown in Fig. 29; appearance after test in Fig. 30.

Description of Failure. At load of 86,500 lb., clevis tore loose from clevis pin on one side; $1\frac{1}{4}$ in. sheave pin badly bent, $\frac{5}{8}$ in. tail bolt badly bent and ring filler split on center segment of tail bolt. After test, inside sheave revolved easily, one outside sheave jammed tight, one outside sheave revolved with difficulty.

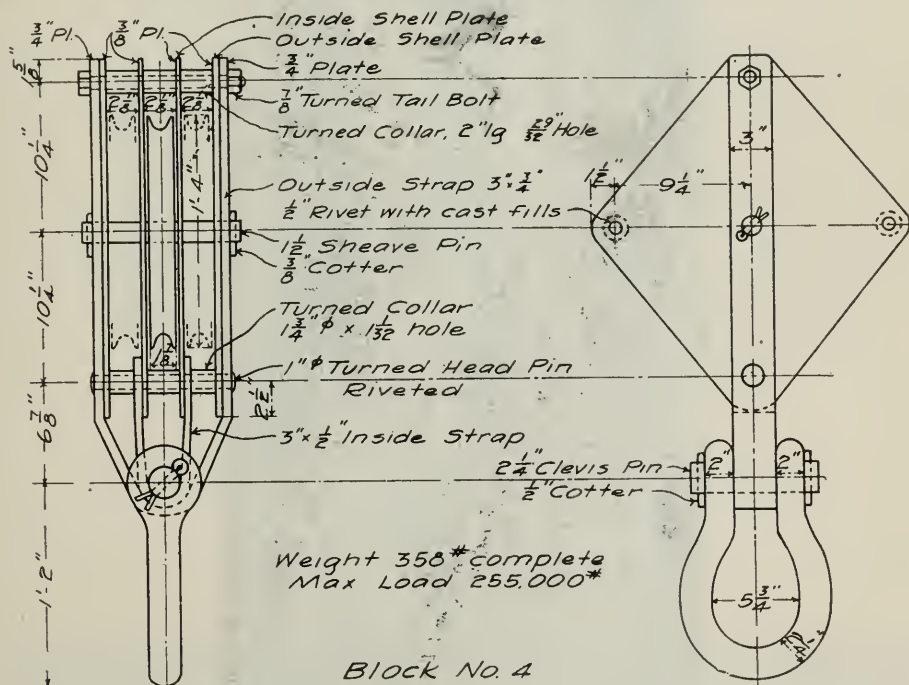


Fig. 31.

BLOCK No. 4.

Weight of block complete, 358 lb. Maximum load, 255,000 lb.

Test of Block No. 4. End of cable was fastened at center segment of tail bolt; details of block shown in Fig. 31; appearance after testing, Fig. 32.

Description of Failure. At 150,000 lb., load was released; no sign of failure. At 170,000 lb., load released; clearance observed below tail bolt; clevis scaling on inside; clevis pin bending. At 188,000 lb., load released; clevis scaling all over; inside and outside straps scaling; inside strap moved down at least $\frac{1}{8}$ in., mark seen at top of strap. At 208,000 lb., load released; clevis pin easily seen to be bent. At 247,000 lb., cotter sheared off on clevis pin on one side; head pin bending up. At 255,000 lb., cotter on sheave pin sheared off on one side, load dropped to 229,000 lb. and blocks failed with loud report.

August, 1909

Condition of Block After Failure. Sheave pin was sheared off at edge of strap. Just before failure center section of head pin above clevis pin was seen to be distorted; when block failed this pin had failed in double shear at inside straps. Tail bolt was sheared off at outside strap. Side straps spread apart from shell plates. One sheave came entirely loose from block and was left hanging suspended in cable.

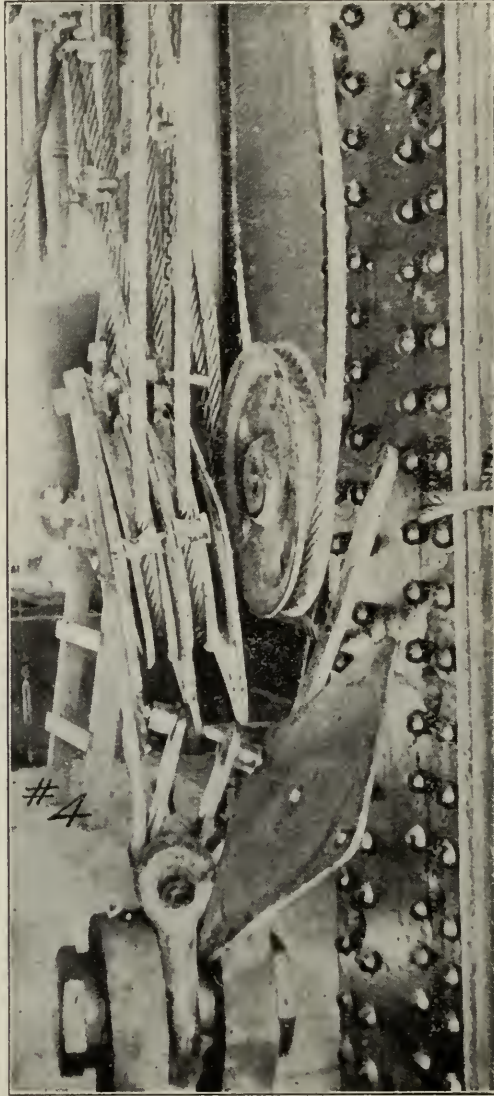


Fig. 32.

BLOCK No. 5.

Weight of block complete, 350 lb. Maximum load, 258,000 lb.

Test of Block No. 5. This block was tested three different times. Details of block shown in Fig. 33; appearance after tests in Figs. 34 and 35.

First Test. Block was pulled to 196,000 lb., when rigging in

testing machine broke. End of cable was fastened to outside segment of tail bolt. Tail bolt was bent in block where cable was attached. No other sign of failure noticed.

Second Test. With cable undisturbed from first test, block was pulled again. At 235,000 lb. clevis pin began to bend, causing block to skew upward on side where tail bolt bent. Pin hole in plates at clevis much elongated. At 255,000 lb., $\frac{3}{4}$ in. tail bolt sheared off

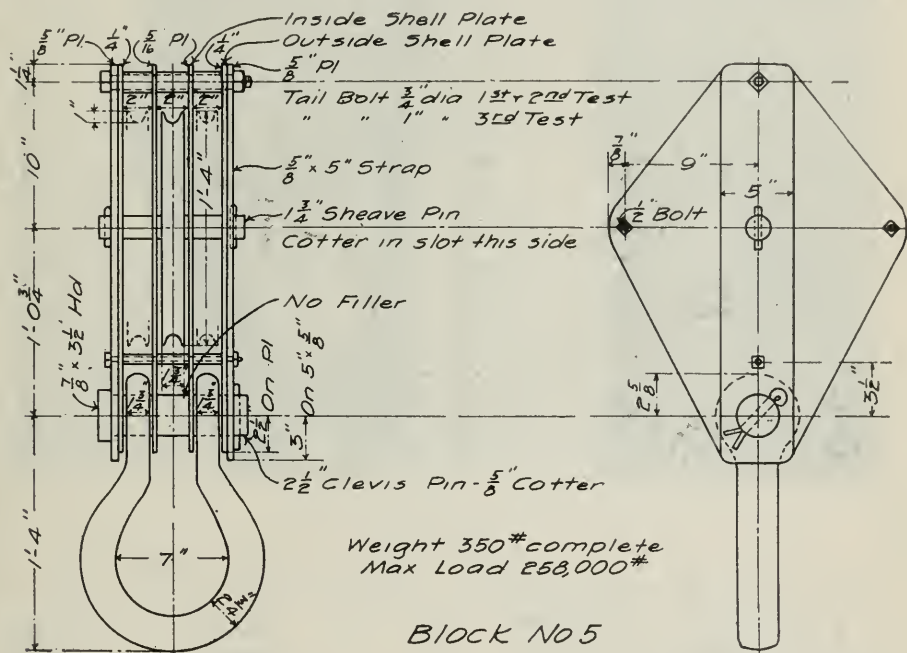


Fig. 33.

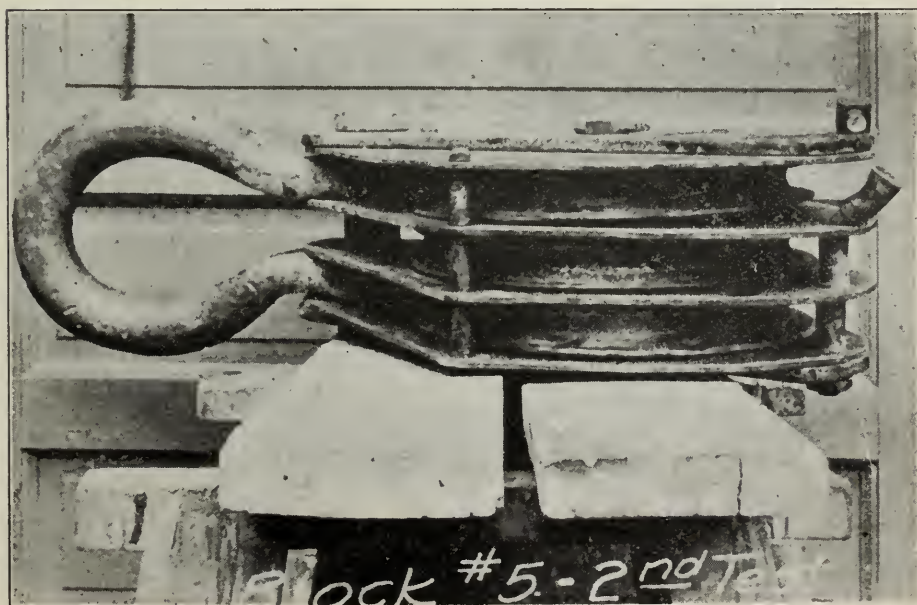


Fig. 34.

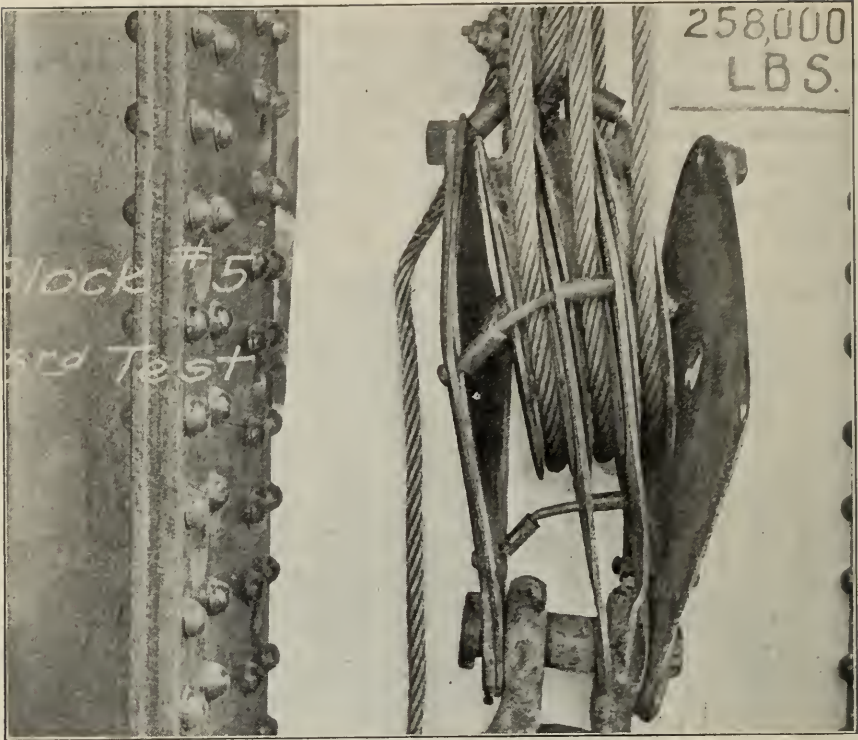


Fig. 35

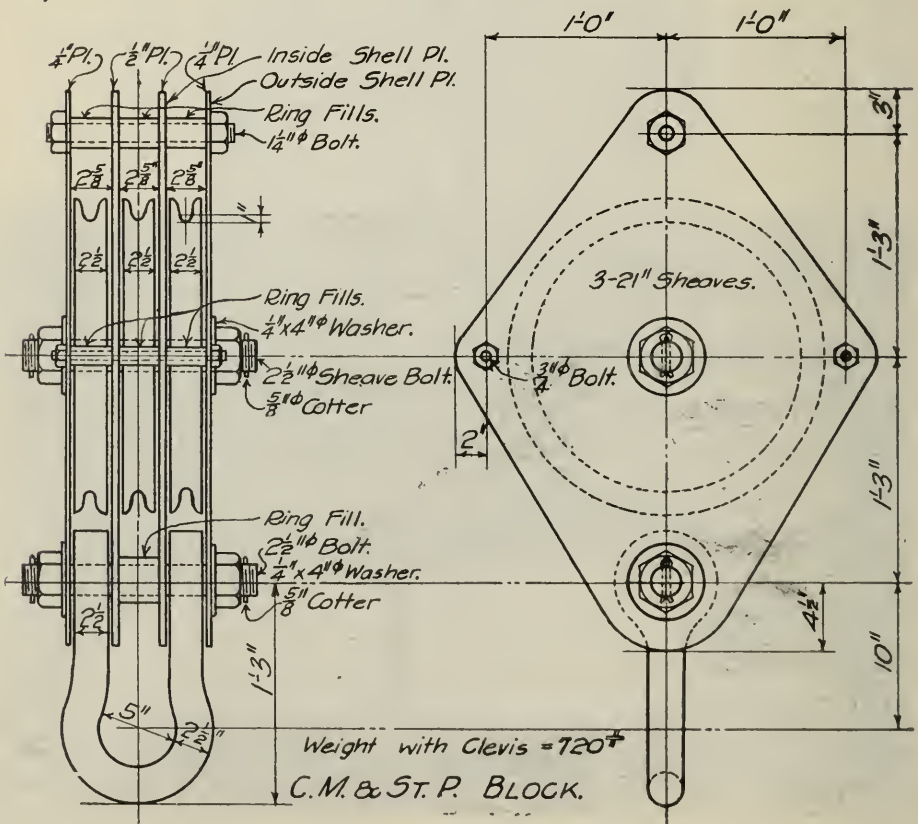


Fig. 36.

with a loud report. As only the tail bolt had failed where cable was attached, it was thought advisable to put in a larger tail bolt and test the block to complete destruction.

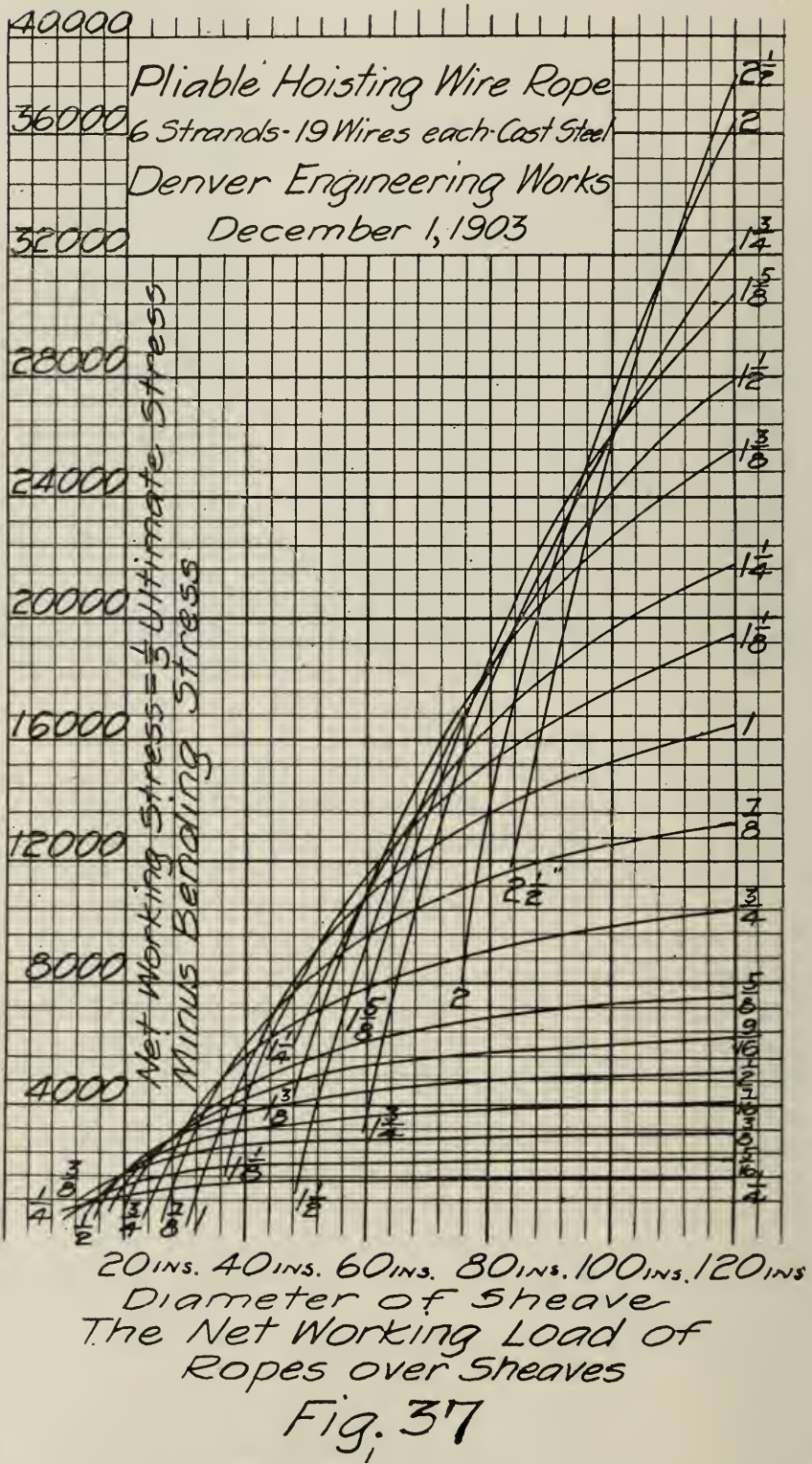
Third Test. Old tail bolt was removed and a 1 in. wrought iron bolt was substituted, the holes being drilled larger in block. This bolt was taken from block No. 1. End of cable was fastened at center segment of tail boat. Load of 158,000 lb. was applied and released; tail bolt was observed to be slightly bent. Maximum load applied was 258,000 lb., after which load was released and block examined. Sheave pin badly bent, cotter broken off; both inside shell plates split; tail bolt bent upward; both inside shell bolts had moved upward $\frac{1}{4}$ in.; due to bolts and sheave pin bending. Load was reapplied to get complete destruction: at 255,000 lb. inside shell plates had raised $\frac{3}{4}$ in. and load began going back until about 178,000 lb.; at this load block burst apart with a loud report. Just previously inside shell plates had raised $1\frac{1}{2}$ in.

Condition After Failure. Clevis pin almost straight. Both inside shell plates pulled through at bottom. Straps and outside shell plates intact at bottom. Sheave pin bent U shaped; ends bent downward at 45° angle. One sheave cracked at hub, by bending of sheave pin. Tail bolt bent U shape, raising center shell plates about $2\frac{1}{2}$ in. above outside shell plates. Tail bolt broken at outside shell plates, single shear. All three $\frac{1}{2}$ in. bolts failed. Both outside shell plates bent away from sheaves, leaving 2 in. and $3\frac{1}{2}$ in. spaces between sheave and shell plate on opposite sides. Both cotters gone in sheave pin. Clevis scaled but in good shape. Clevis pin slightly bent. Straps badly bent and separated from shell plates. Holes elongated and straps dented by head of cotter. Holes badly distorted at sheave pin in outside shell plates.

In General:—The weights of the several blocks tabulated show that the Milwaukee block, Fig. 36, weighs somewhat more than twice as much as the blocks which it tested to destruction. This additional weight, however, was not due to heavier construction throughout, but was mostly due to the use of 21 in. sheaves, in the Milwaukee block to reduce the bending stresses in the wire rope.

These 21 in. sheaves are from 30 to 50% greater diameter than the sheaves in the other blocks, and as shown by Fig. 37, a $\frac{7}{8}$ in. rope on a sheave of 60 in. diameter will carry a load of 9,600 pounds, but a $\frac{7}{8}$ in. rope on a sheave of 40 in. diameter will only carry a load of 6,000 pounds.

In Fig. 37, which is drawn from tables of the Trenton Iron Company, is given values of allowable loads for use in power transmission, where the number of repetitions of bending and the consequent fatigue of the metal is much greater than in erection work; nevertheless it illustrates the point in question, although it was made for much greater diameter of sheaves than were used in the derrick car.



DISCUSSION.

Mr. O. P. Chamberlain, M.W.S.E. (Chairman): The paper before us tonight is one of the leading topics of the day. Distinct advances in bridge construction have been made in passing from the old wooden bridges and trusses to the steel structure of today. We have at the same time, or perhaps closely following, made rapid advancement in the method of construction, abandoning, to a great extent, the former methods of invariably erecting false-work on which to build our structures, and doing the work now largely by means of travelers, advancing on the new structure as it is constructed, and perhaps a little later in the development of this line of construction by the use of derrick cars.

Mr. G. W. Smith, M.W.S.E. (by letter): The paper presented by Mr. Prior on the subject of Derrick Cars and Bridge Erection is very interesting and, particularly so far as it relates to derrick cars, is especially valuable because it treats very fully of a type of equipment which is comparatively new and in a condition of development. Travelers for bridge erection are, to a large extent, temporary and are designed for specific cases or for a limited series of operations. Derrick cars, on the other hand, are permanent equipment, the wide usefulness and possibilities of which are not yet perhaps generally appreciated.

Probably the best field for discussion is with regard to the limitations, if any, which will prescribe the usefulness of the derrick car and various general features of its design which add to its versatility without increasing its weight or expense. The matter of clearances and proper proportions of the various members can be left for calculation.

The economical limit in the use of the derrick car is reached on a single track line when the material must be delivered on the same track used by the derrick car and from such a distance as to make the ultimate expense greater than would be incurred in the use of a traveler which would permit the delivery of material and the passage of trains through its framework. The limits to the capacity of the derrick car are not so easily established because conditions constantly change. The fifty ton derrick car described in the paper is one of the most modern in design and is probably one of the heaviest cars built. If the weight of the car and the length of boom cause no difficulty or inconvenience in transportation or in service it is of course within the practical limits for the design of such equipment. It would be interesting to know the weight of this car on each truck when in shape for shipment and the weight on the front truck when in operation, carrying its maximum load in front with the boom well extended. It is not unusual to find newly constructed railroad track which is not safe for such loads.

In the practical operation of derrick cars the following features are found to be of value:

1. Side booms to secure lateral stability.

2. A connection with the front truck for propelling the car.
3. Three or more axles and wheels under the front end of the car.

Booms for the purpose of securing lateral stability can be attached on each side of the head frame and can occasionally be used for other purposes. They need not be permanently attached to the car but the car should be designed so as to permit their use when necessary. Connections for the purpose of counteracting an eccentric load are much more readily provided for in this way than by using guy lines from the top of the headframe.

It is evident that when the car is moving with the load in front of it the weight upon the rear truck is greatly reduced. In fact it sometimes becomes impossible to propel a car on wet rails or up-rising grades on account of the small weight on the rear wheels. If the propelling device is attached to one of the front axles, however, this difficulty is avoided.

The added number of axles under the front end of heavy derrick cars becomes necessary in order to protect the track and to avoid the use of special journals.

Mr Prior: Referring to Mr. Smith's suggestion of placing a propelling device on front truck;

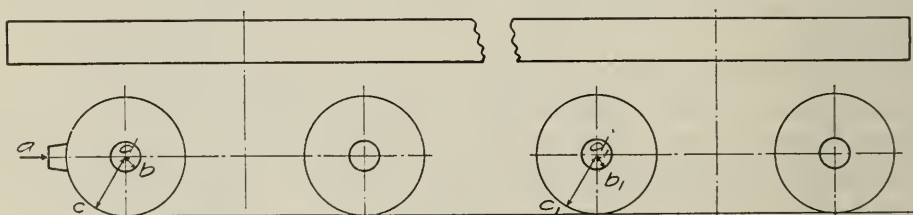


Fig. 38

The frictional resistance due to the weight of the car itself must be overcome in order to cause motion. However, the force necessary to apply at the point "a," Fig. 38, is less than the friction to be overcome at the point "b" and "b'," by the ratio of the radii "bd" to "cd," and the friction at the point "b" and "b'" being friction of lubricated metal surfaces is small. This explains why the small tractive effort which can be developed by the adhesion of the lightly loaded rear truck wheels to the rail is sufficient to propel a car when carrying a load. The difficulty in placing the propeller on the front truck is due to the fact that in that case, the chain wheels which are operated from the front axle of the engine are inconveniently distant from the engine.

Mr. Smith mentions the use of side booms to secure lateral stability in the operation of derrick cars. Referring to Fig. 15, cross section "CC," at the top of the "A" frame is located a three-inch pin; from this pin is suspended a block and tackle, ordinarily used for lateral guying. The block and tackle are left in this position practically continuously so that at any time the car can be guyed from this point, which affords a lever arm of from 14 to 20 feet above the

top of rail, depending upon the angle of the guy with the horizontal.

Mr. Smith also suggests the use of additional axles on the front truck to protect the track from the heavy axle concentrations. This truck was not designed by the Bridge and Building Dept., but I can say that during shipment the weight on the front truck is 101,000 pounds. This makes the reaction on each axle about equal to the driver axle concentrations of a Cooper's E-50 locomotive, which is not uncommon. The weight of the rear truck is somewhat more, but this is not equal to the axle concentrations of Cooper's E-50 alternative loading for short spans, which consists of 60,000 pounds on each of two axles 6 ft. 0 in. centers.

When the car is ready for use the distribution of weight between the trucks is practically reversed, the weight on the front truck in some instances amounting to 120,000 pounds. Mr. Herlihy, who erected a large part of the work mentioned, can say whether or not the driving wheels slipped under heavy loads.

Mr. F. J. Herlihy: We had no trouble whatever in propelling and getting the required adhesion to the rails.

Mr. I. F. Stern, M.W.S.E.: The C. & N. W. Ry. Co. has never gone into anything so elaborate as this work of the C. M. & St. P. Ry. described by Mr. Prior. We have three derrick cars which have a capacity of only about 20 tons each, and where we have to lift anything as heavy as 35 tons we use two derrick cars. Our cars are not self-propelling and we have been limited in our work to the equipment we could get. We have been talking derrick cars for a long time to our superiors and perhaps the paper tonight will help them to come to a decision. At present the tendency seems to be, among railroad companies, to contract for the heavy work and do the lighter work, such as on track elevation or on spans up to 150 ft. in length, with their own forces. We have attempted to show by means of cost figures that we could effect a saving by the use of high power large derrick cars, but our superiors apparently do not seem to have sufficient confidence in these figures to allow the purchase of such a car.

We believe emphatically in the use of derrick cars for erection purposes, and the derrick car work as used on the "Northwestern" road and as developed by Mr. Finley is a part of our ordinary work in that line. When he started in we were using travelers for say 130 ft. spans, and for that sort of work we now use derrick cars. In connection with the Mississippi river bridge the contractors put up a 202 ft. span with a derrick car and the operation worked out very nicely.

As I said before, we do the lighter work with our own forces, putting up our track elevation steel with derrick cars, and have been able to do good work; we found we were able to put in four tracks on standard 66 foot crossing in one day of eight hours, and while that has not been done every day we were able on our last track elevation work to approach it very closely most of the time. I think the derrick car has come to stay, judging from our experience and

the experience of the "St. Paul" road, and I believe that it is a very economical method of erection.

The great question, of course, has been whether the railroad company was to be regarded as a construction company or purely as a transportation company, and the point of view has seemed to be that the railroad company is a transportation company only, and that all large construction work should be turned over to contractors. In fact this tendency has been to emphasize the development of large firms like the Westinghouse, Church, Kerr Co., and allow them to handle entire contracts with its attendant engineering. While that is possible, we all hope and believe that we can develop the kind of equipment we need. The larger question is whether it is policy for the railroad company to do its heavier work. I am glad to know of this experience of the "St. Paul" road in doing its own work and I think that question is going to be threshed out considerably, within the next few years.

It would be very interesting if the "St. Paul" road could consistently publish its figures of cost, for that is one argument that will most influence the railroad companies in this matter. It is our desire to do these things, in construction as well as design, to develop our engineering department,—doing the greatest work we can in the way we ask to do it because we think we can do it cheaper than by contract, and that I think is the question that is to be discussed.

Mr. C. F. Loweth, M.W.S.E: The question raised by the last speaker as to whether it is desirable for a railroad company to do large construction work with its own forces or contract it is, perhaps, too large a subject to discuss this evening. However, my observation is that there is a decided tendency on the part of railroad companies to do more and more with its own forces, the kind of work which has been described tonight. The time was, and that not many years since, when it was the almost universal custom for railroad companies, when a bridge was to be built, to call on the contractors to both design and erect it. Now, I think, it is much more frequently than otherwise the custom of the railroad companies to design the work in their own offices, and to erect the structure with their own forces.

I am glad the matter of the relative advantages of derrick cars and travelers has been brought up. Spans of considerable length can be readily erected with derrick cars; the Chicago, Milwaukee and St. Paul Railway Company has recently erected, with derrick cars, several spans as long as 270 feet, and I have no doubt we could have put up even longer spans by such means. As a general proposition, however, the speaker thinks that for long truss spans, especially where there are several in the same bridge, the work could be better done with a traveler. With a traveler the work can go on with little interruption from or to traffic. A larger force may be employed and the work pushed more rapidly.

If derrick cars are used, the work of erection is frequently delayed, and sometimes entirely ceases while the derrick cars are run back into the clear for regular traffic. On the other hand, the use of a traveler requires a wider falsework than does a derrick car, as the traveler must generally have its tracks outside of the new structure. This additional falsework is oftentimes a consideration which would influence decision in favor of the use of derrick cars.

On new tracks where there is no traffic to be taken care of, or on branch lines where the traffic is not frequent and for bridges where there are not more than two or three spans and where the work is not urgent, it is probable that derrick cars would be more advantageous than a traveler.

During the past two years, during the construction of the Pacific Extension of the Chicago, Milwaukee & St. Paul Railway, the equipment which the author has described has been ample in putting up about five and three-quarters miles of steel work, including spans up to 425 feet in length, and, while we know that it could be improved on, we have the satisfaction of knowing that it has very efficiently done the work for which it was designed.

The speaker wants to emphasize the credit which Mr. Prior has given in his paper to the several assistants who worked out in detail the problems assigned them, and he wishes to include in this mention the author of the paper himself, who, together with the others mentioned, did their work so efficiently.

Mr. Prior: Mr. Stern referred in his remarks to erection costs. At Cow Creek the cost of erection was \$1.90 per ton, exclusive of riveting; the cost of riveting, etc. was \$3.10, making a total of \$5.00 per ton.

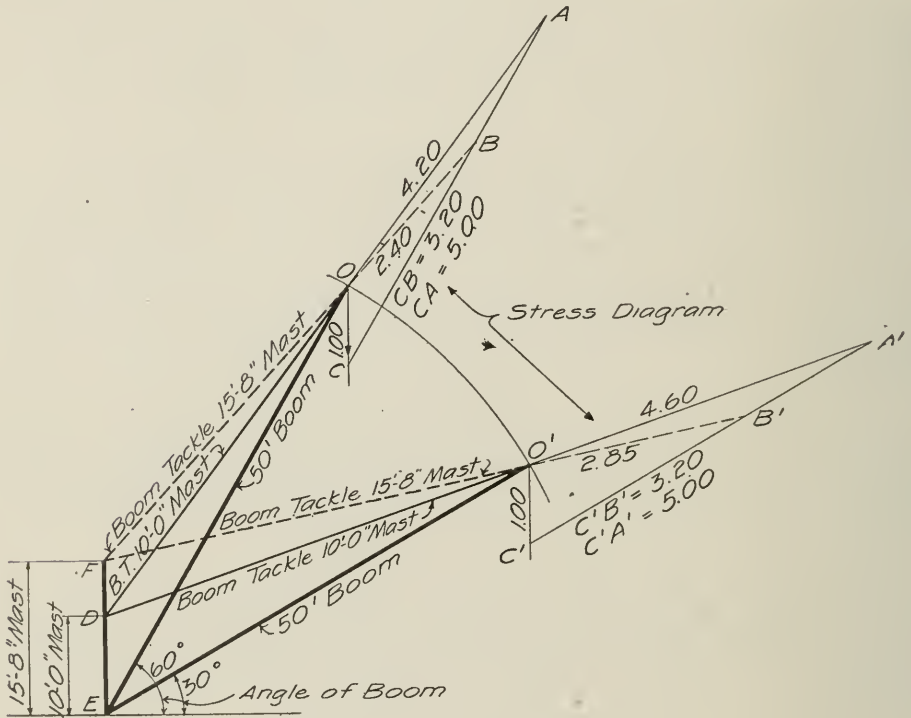
In regard to whether a railroad company is a transportation company or a construction company, it is, of course, a transportation company. But in transportation the safety of not only the freight traffic is involved, but, much more important, the lives of its passengers. So, whatever way it may be looked at, it is beyond question that the railroad company will certainly protect its greatest and most vital interests with greater care than a stranger.

Mr. E. N. Layfield, M.W.S.E.: I think it would be interesting to those present if Mr. Prior would state whether there was any particular reason for the difference in design of the tower and the A-frame on those two cars. Doubtless there is some good reason but it did not appear to me just what it was.

Mr. Prior: When the 30-ton car was designed, it was the intention to use the car without the "A" frame for all ordinary purposes, but for loads greater than the ordinary, to place the "A" frame on top of the car, and operate the car at its increased capacity. We find, however, that when an erection device is placed in the hands of field forces, so many new uses are found to which it can be put when rigged to its maximum capacity, that it is rarely used when rigged in any other manner. In the case of the 30-ton car the "A"

frame, instead of being used occasionally, has been continuously used, together with the tower for lifting loads which could not be lifted by the tower alone.

On the 50-ton car we started out to design a heavier equipment and we knew that the highest mast available would be the only one used. The mast was therefore made as high as possible for the following reasons: If we increased the height of the mast as shown



Derrick Car Stresses
Fig. 39

in Fig. 39, "OC" represents graphically the unit load suspended at the end of the boom. Then "AO" and "AC" represent the stresses respectively in the boom tackle and in the boom for a 10 ft. tower. If, however, the height of the mast is increased so as to raise the top of the mast from the point "D" to the point "F" the stresses in the boom tackle will be represented by the line B-O, and will be reduced by a large percentage—in this case the reduction being 43%. Incidentally the stress diagrams in Fig. 39 show that the direct stresses in the boom are constant for all angles less than 90 degrees with the horizontal.

Mr. W. E. Symons, M.W.S.E.: A number of interesting points have been brought out in the discussion in connection with this car and its operation, and as one is liable to be led a little away from the real subject, should I digress, I hope you will either pardon or correct me.

Referring to the feature mentioned by one of the previous speakers, with respect to railroad companies manufacturing certain devices or

portions of equipment for their bridges, it has been quite noticeable in recent years that there is a diversity of opinion and thought as to the advisability or, one might say, the economy of this course. When properly analyzed it may be, sometimes, the result of conditions beyond the control of the management of the property. It is very noticeable that some large companies only repair their equipment, and when they have any large amount of heavy work they have it done by outside contract. Some lines have even gone to the extent of closing down and dismantling their iron and brass foundries, purchasing castings on the outside. The same is true of their purchase of other material, particularly bridges.

It is very gratifying to know that a progressive road like the C., M. & St. P. Ry. has branched out in building derrick cars for the erection of bridges, more elaborate than anything used by any of the other roads, and in many cases more elaborate than is owned and used by the bridge companies.

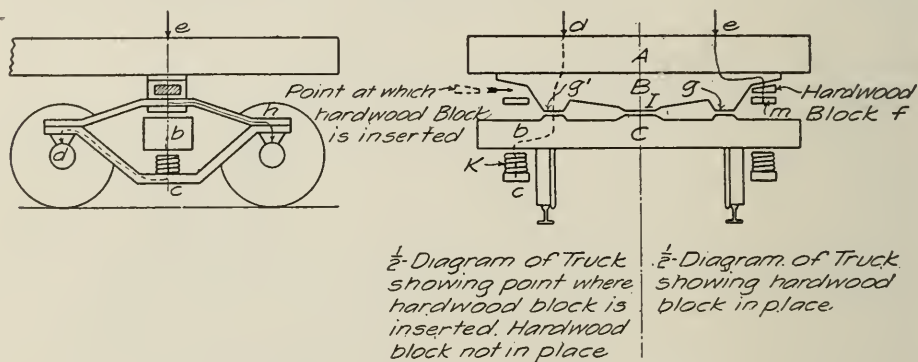
One of the questions asked, and which was partially answered by the author, was that there seems to be some doubt as to the adhesive capacity of the car to propel itself under certain conditions. If I understood the figures correctly, the car has a total weight of 234,000 pounds, and when in operation, under normal conditions, the rear trucks, as shown on the screen, support about 123,000 pounds. If these figures are correct, then on that basis the rear wheels would have a tractive effort of about 16,000 pounds. One pair of wheels would provide about 8,000 pounds tractive power, but the car itself, on a level, would only require a tractive effort of about 1,000 pounds to propel it. Therefore, if my calculation is correct, the car is amply supplied with tractive power. I should be glad, however, if the author would advise us on that subject in his closure.

It seems to me, too, that there may be some possibility of the car giving trouble from hot boxes, although well supported from the standpoint of strength. Assuming that the journals are about 6 in. by 10 in., the weight per square inch of projected area would run up in the neighborhood of 480 lbs. per square in., which would be somewhat excessive as a general proposition.

In regard to the placing of blocks between the body bolster and arch bars. I presume that is when the car is in operation and is intended to steady the car and keep it from tipping over, this method being used to shift the load from the side bearing. There is quite a difference of opinion among engineers and transportation officers as to the proper location of side bearings on locomotives, cars, and other equipment. Some roads say that 48 in. is the proper location for side bearings and that it is not good practice to put them out any farther, while others say that 60 in. is the proper location and that 48 in. does not contribute to a safe moving vehicle. The location of the side bearings and amount of clearance which is given them, together with an explanation as to the benefits it is expected to secure

from placing the blocks on the arch bars, would be of considerable interest, in that the derrick car in operation or movement on the track is a good deal of the same character as a refrigerator car, especially when used for transporting dressed meats, and carries near the roof an additional load of about 12,000 lbs. of ice. If there is any one place that is considered more desirable than another for side bearings on refrigerators, it would be reasonable to assume that a similar location would be suitable for the derrick car in question.

Mr. Prior: Referring to Mr. Symons' question as to the benefit expected from placing the hardwood block on arch bars. We did not design the truck, but the action due to the hardwood block can be explained roughly as follows: In Fig. 40, which is a diagram



Blocking of Trucks under Load
Fig. 40

only and in which the details have been altered to reduce the number of lines, "A" is the car body and "B" is the body bolster, resting through the center bearing "I" on the truck bolster "C," the body bolster and car body being prevented from tipping sideways by the side bearing "g." When the hardwood block is not in place an unsymmetrical load, such as "d" would be transmitted roughly as shown by the dotted line from the car body "A" to the body bolster "B," from the body bolster "B" through side bearings "g" to the truck bolster "C," through the springs "K" through the side frame "c," and thence through the journal boxes to the axle. If this block is inserted as shown in Fig 40 at "f" between the body bolster "B" and the upper arch bar "m," then loads which are carried by the springs before the hardwood block is inserted, will be carried by the springs after the hardwood block is inserted, but if an additional unsymmetrical load, such as "e," be placed on the car, as would be the case when a load suspended in the boom was swung sideways, the unsymmetrical load "e" will be largely transmitted from the body bolster "B" through the hardwood block to the upper side bar "m" to the point "h," where it will be transmitted by the axle boxes to the car axle.

Regarding the propelling device, Mr. Symons gave 1,000 pounds

necessary to propel the car and 7,000 pounds available, with the conclusion of ample tractive effort. With the relative figures at hand I would say that it was all right, but I think the margin is somewhat less between that than 1,000 and 7,000 pounds.

Mr. Chamberlain: One feature of this paper is particularly interesting to me, and that is the description of the work in progress, as shown in Figs. 4 and 5, in which with a 30 ft. derrick car the columns were placed by out-hauling. I remember that, quite a number of years ago, when I had charge of the erection of some viaducts on the Pennsylvania Railroad, we had considerable difficulty in handling some columns, which came 84 ft. long; the work was not done with a derrick car but with a traveler. It seemed to me, as I heard this description and looked at the illustrations, that it was rather a hazardous piece of work to out-haul those columns for a distance of 36 ft. and I will ask whether, in handling the columns in that way, they were handled in entire safety or if there were some accidents.

Mr. Herlihy: We did not have any difficulty in out-hauling; at first the men seemed a little timid, but it was the only thing we could do; we only had the 30-ton car and had to devise some method of erecting the steel. We had to out-haul 36 ft. It was done by first lifting the load to the required position, then putting on the two out-hauling lines and stretching clear across the canyon.

We passed the out-haul lines through a single sheave block, securely fastened by a pendant line, and thence back to an independent winch-head on the engine. We had only two winch-heads to do the work with. We out-hauled three or four pieces, and after getting used to the operation, we had no trouble.

Mr. Loweth: The methods of erection shown in Figures 4, 5, and 6 were resorted to not from choice but from necessity. It was the intention that this viaduct, and another one quite similar nearby, should be erected by the use of the traveler described in the latter part of this paper, but many of the important parts of this traveler, together with a large portion of our bridge erection crew, were unable to reach the site of the work, by reason of the extensive floods through western Montana, which put out of service all the trans-continental lines for a period of about twenty-five days. Meanwhile, the track-laying had reached this viaduct site. We had a small derrick car and a small crew of men available and all of the steelwork, and it was necessary to do something, and the illustrations show what was accomplished with the means at hand. This viaduct was not only erected but the other one partly completed before we were able to get the material moved. The illustrations are of value as showing the adaptability of the derrick cars and what can be accomplished by them when necessary.

Mr. Chamberlain: I understood from Mr. Prior's paper that perhaps this method was not recommended, and it speaks well for the method that the work was handled as well as it was.

Mr. F. R. Judd, JUNIOR, W.S.E.: I would ask if regular gangs of men connected with the Bridge Department were employed on this work, or if special men were hired for each job? If the former is true, are the men paid the regular "Union" prices? It occurred to me that perhaps a portion of the saving was in connection with the labor, and that it was possibly not all due to the arrangement of handling the material with the car.

Mr. Herlihy: Mr. Loweth has information regarding the prices paid the men, which I believe were about the same as usual. I think the speed with which the work was done was due almost entirely to the superiority of our equipment and to that alone.

Mr. Loweth: In answer to this question, the speaker would say that the Chicago, Milwaukee and St. Paul Railway Co. aims to keep an organization of skilled iron bridge men constantly employed. The force will vary, depending upon the amount of work to be done. I think we have never had less than thirty-five or forty men on our payrolls, and frequently we have had one hundred or more. An effort is made to so arrange the work as to keep the nucleus of an organization of this kind constantly employed, thus enabling us to give enough men permanent work to maintain an organization of reliable and experienced men.

The rates which have been paid east of the Missouri River have been \$3.50 per day of ten hours, except for work inside the larger cities, where the local union rates prevail. West of the Missouri River and on all the work done on the Pacific Extension, the rates paid for skilled men have been \$4.00 per day of ten hours, and all of this work has been done so far with union men, although we are now using some non-union men in western Montana, due to disagreement with one of the local unions.

Mr. O. E. Strehlow, M.W.S.E.: Prior to hearing the paper presented, I put down a few "don'ts" which I keep in mind in making a design for a derrick, machinery, etc., and I give them as follows:

Don't use cast iron.

Don't use small sheaves and drums.

Don't use set screws.

Don't use worm gears.

Don't use a cotter pin through nut.

Don't use sheaves loose on shafts.

Don't use cone-frictions.

Don't use customary factor of safety.

Don't fail to provide efficient and simple lubricating devices.

Don't fail to make everything fool proof.

By elimination of the above as far as practicable the lost time due to breakdowns, especially for fast continuous service, will be reduced very considerably.

THE ENGINEERING EXPERIMENT STATION AND ITS RELATION TO ILLINOIS INDUSTRIES.

L. P. BRECKENRIDGE, M.W.S.E.

Presented May 5, 1909.

The State of Illinois is most advantageously situated in relation to the continually increasing industrial activities of the Middle West. The wonderful fertility of its soil has made it for many years foremost in the wealth of agricultural products. The climate and rainfall have favored the production of immense crops of corn, wheat and oats, and fully 75 per cent of its great area (56,650 sq. mi.) has been prepared for cultivation.

Its fuel supplies are enormous, its yearly product is next to Pennsylvania in amount and it probably has within its borders today more bituminous coal of usable grades than has any other state. It is not strange that to these fertile fields came many settlers. It is not strange that on the edge of its Great Lake was planted its now great city. After people come, transportation is provided, then manufacturers follow to supply the needs of the people. Then more people come to distribute the products of farm and factory, wealth accumulates, and still more factories are built to supply luxuries as well as needs. State and municipal institutions spring up and multiply. Provision is made for the penal, charitable and educational needs of state and city. What seemed large provision soon becomes inadequate and the work of a few years ago must be torn down and in its place must be put up again a new and larger and more modern structure. The stores and bank and the library are all soon too small and must be built anew. So it has been with Illinois, so it is now with Illinois. A great agricultural, a great mining, a great manufacturing, a great commercial, and a great transportation State, teeming with a vigorous, wide awake, progressive population surpassed in numbers only by New York and Pennsylvania and surpassed in opportunities and energy by none.

The story of the growth and development of the industries of Illinois is most interesting. The growth has been rapid and natural. It has not been held back by any natural barriers and progress has been easy compared with that of some of the states earlier settled. There are a few significant facts which should be continually before the citizens of Illinois. These facts should make them feel the possibility of accomplishing great undertakings, and should impress upon them the responsibilities which their wealth, their position and their opportunities impose. To some of these interesting facts your attention is directed under the heading of

ILLINOIS—A GREAT INDUSTRIAL STATE.

(a) The population of Illinois is about 5,500,000, which is approximately 1-14 of the population of the United States. Exceeded in population only by New York and Pennsylvania.

(b) Illinois stands second in the value of its agricultural products, for 1908 the value being about.....\$550,000,000

(c) Illinois stands third in the value of its manufactured products, for 1908 the value being.....\$1,600,000,000

(d) Illinois stands second in tons of coal produced, the value of product for 1908 being about (51,000,000 tons).....\$54,000,000

(e) Illinois stands second in barrels of oil produced, the value of this product for 1908 being about (40,000,000 Bbls.)..\$24,800,000

(f) Illinois stands second in miles of steam railroad, the number of miles in 1906 being about.....12,000

(g) The value of the mineral products of Illinois has increased 65% since 1905. For 1908, which included coal and oil, the value was about\$150,000,000

(h) The capital invested in the thirteen leading industries in Illinois is (1906)\$600,000,000
In the remaining industries..... 375,000,000

Making a grand total of.....\$975,000,000

This amount is now (1909) estimated at about....\$1,200,000,000

The Development of Illinois Industries—By the charts and diagrams which accompany this article it is intended to point out the possibility of the great industrial growth of the United States and to show how rapid has been the development of Illinois as a manufacturing state. The population of the world, Fig. 1, gives promise of a market for the products of our farms and factories if only we are prepared to send them where needed. The citizens of Illinois gave evidence that they were awake to the future possibilities of a foreign market for Illinois products when they voted in favor of the next step in water transportation which must finally end in a waterway from the Lakes to the Gulf.

Illinois, now third in population (Fig. 2), is advancing rapidly and it will only be by taking thought for tomorrow that the future of her interests will be conserved. What will be the population of Illinois in 1950? Perhaps ten millions; the chart, Fig. 3, makes promise of that figure. And Chicago at that date,—will it still be 40% of the State's total, and reach four millions? If so there are many things to be done in the State and city in the next forty years and it is none too soon to start on many of them.

When we see what is the distribution of wage earners, Figs. 4 and 5, among the leading pursuits, it is not surprising that so much attention has been and will be given to those things that pertain to agriculture and to engineering. In Illinois, one quarter of the wage earners are engaged in agriculture while nearly one half are engaged

in pursuits directly related to engineering, such as manufacturing, transportation and mining. This nation has made such great progress because, above all things, it has found near at hand, forests, food and fuel. It has been extravagant in the use of all. Its forests

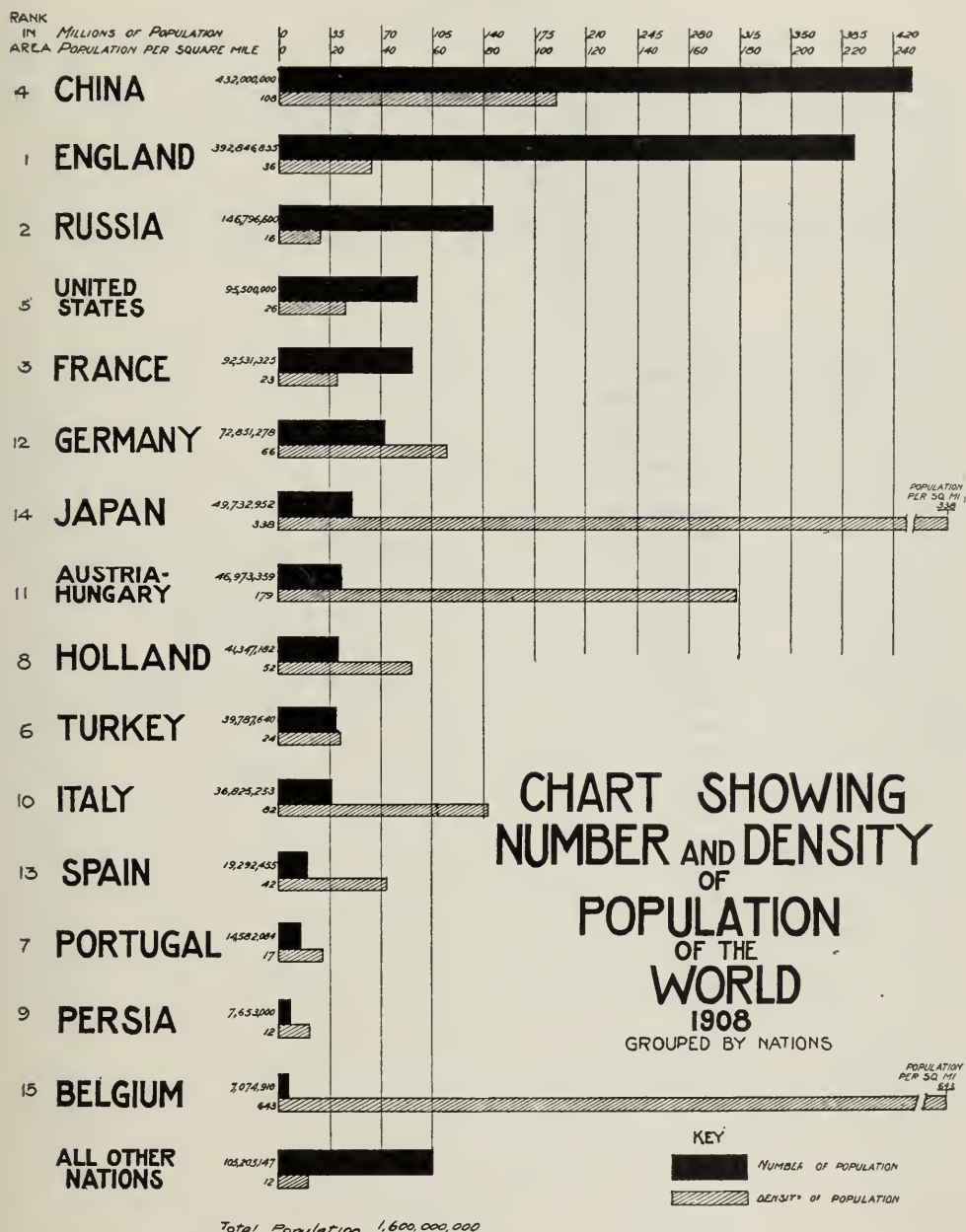


FIG. I.—POPULATION OF THE WORLD

have rapidly disappeared; its land which once raised food is now unproductive; its fuel will last perhaps 600 years; it has apparently begun to think about these things; it will save and renew some forests; it can preserve the fertility of its soil and fortunately here in Illinois that problem is well in hand and the methods for doing it

August, 1909

are available in the investigations of the Agricultural Experiment Station. It can economize in the use of its fuels, it is doing so in all the great plants that manufacture light and power. Not more than one half as much coal is used to produce one horse-power today as

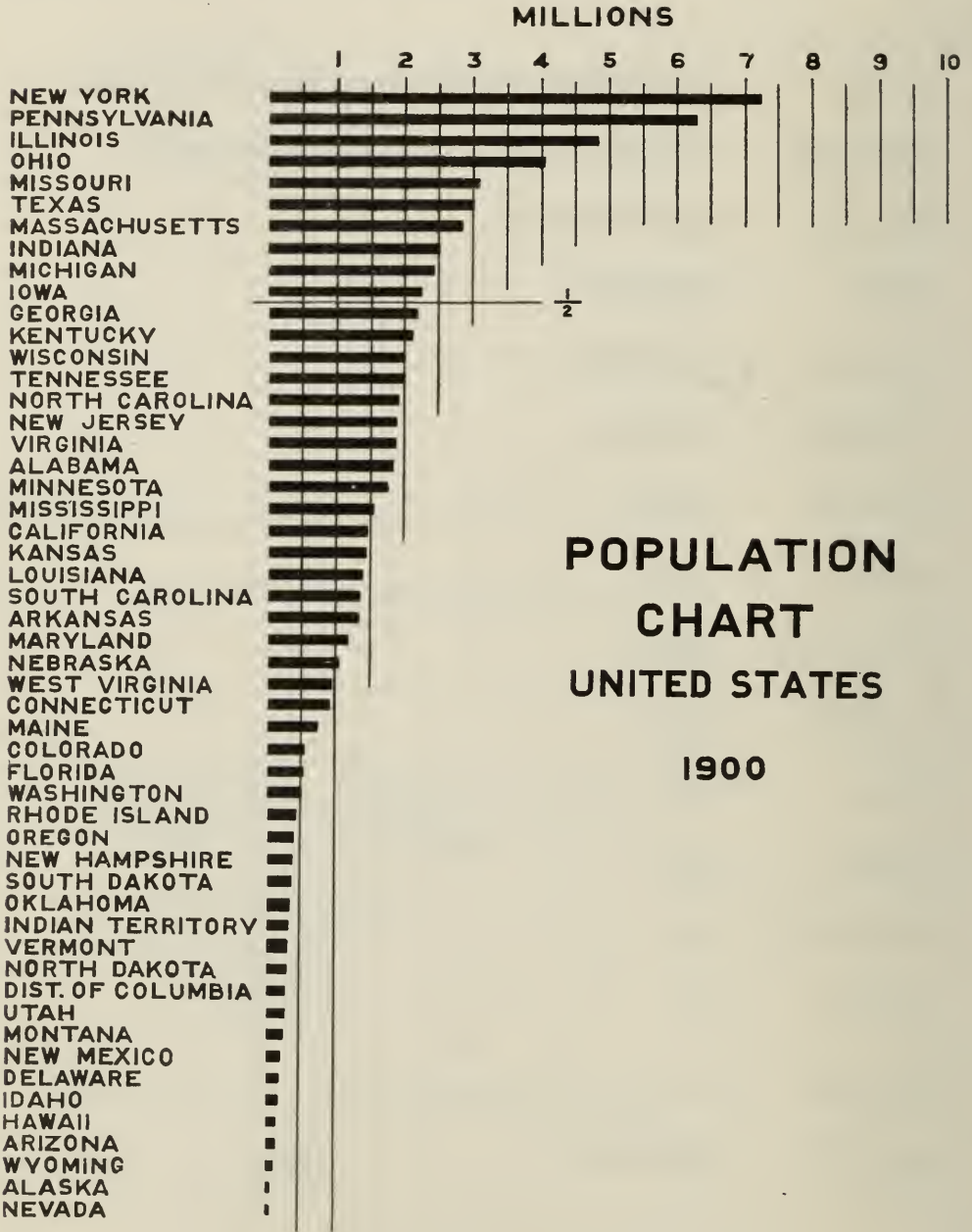


FIG. 2.—POPULATION OF THE UNITED STATES

was used thirty years ago. But fuel must be burned to produce most of our power (Fig. 6) for many years to come. Harness the water whenever you can, but three quarters of the power produced in the United States at the end of the next forty years will be produced by burning coal. Fortunately Illinois has much coal. It is cheaply

mined, and in large plants, located near plenty of condensing water, power can be produced as cheaply in Illinois as it is now produced at the brink of Niagara Falls. But industries prosper, because in

CHART SHOWING POPULATION OF ILLINOIS AND CHICAGO

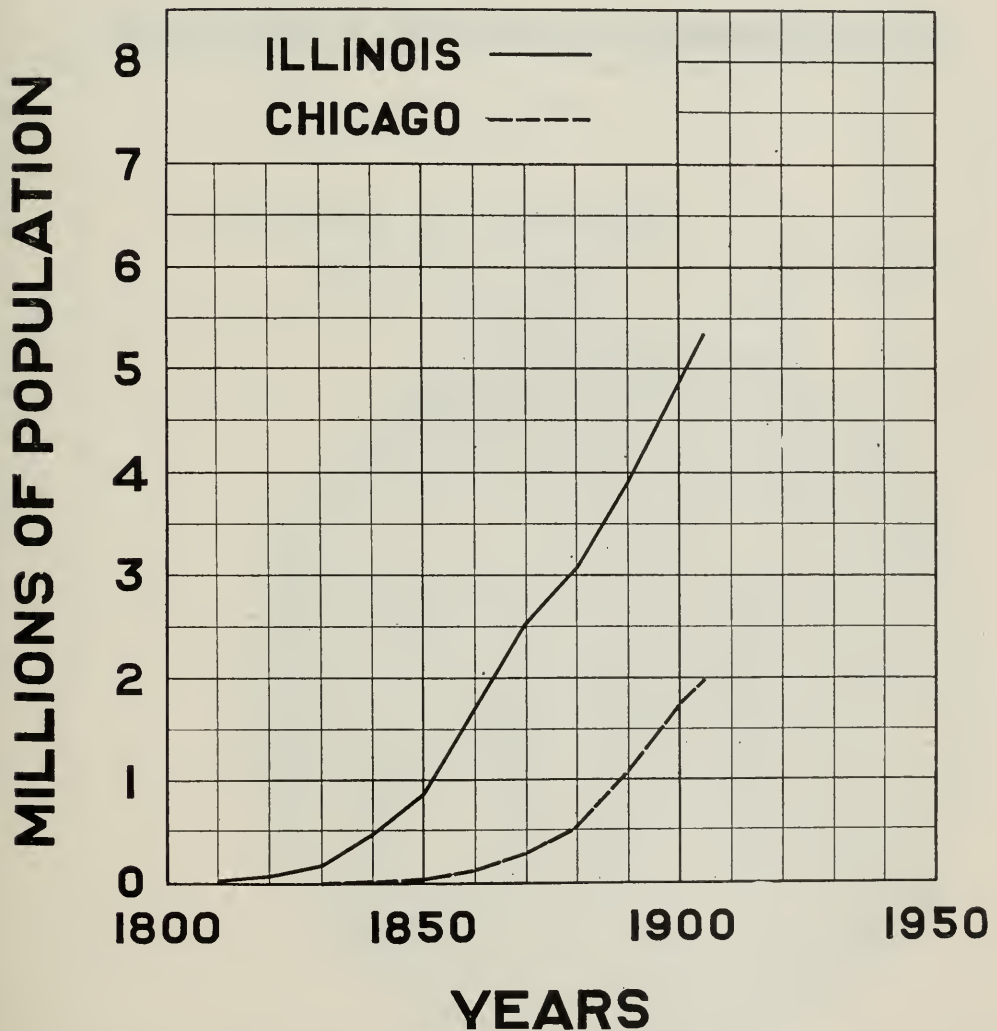


FIG. 3.—POPULATION OF ILLINOIS AND CHICAGO

America we use power for our labor and we make steam and electricity do a rapidly increasing part of the work. In some states it

August, 1909

WAGE EARNERS
UNITED STATES—1900

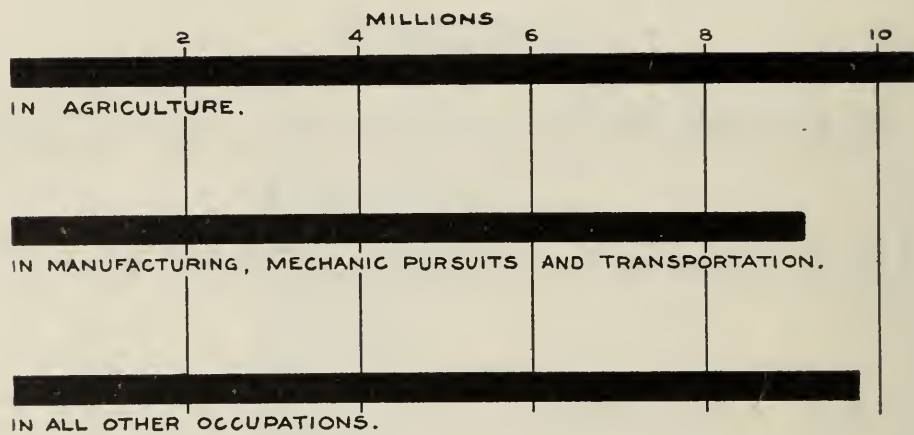


FIG. 4.—DISTRIBUTION OF WAGE-EARNERS IN UNITED STATES

COMPARATIVE NUMBER OF PERSONS
EMPLOYED IN DIFFERENT OCCUPATIONS.
STATE OF ILLINOIS.

BUREAU OF LABOR STATISTICS, 1908

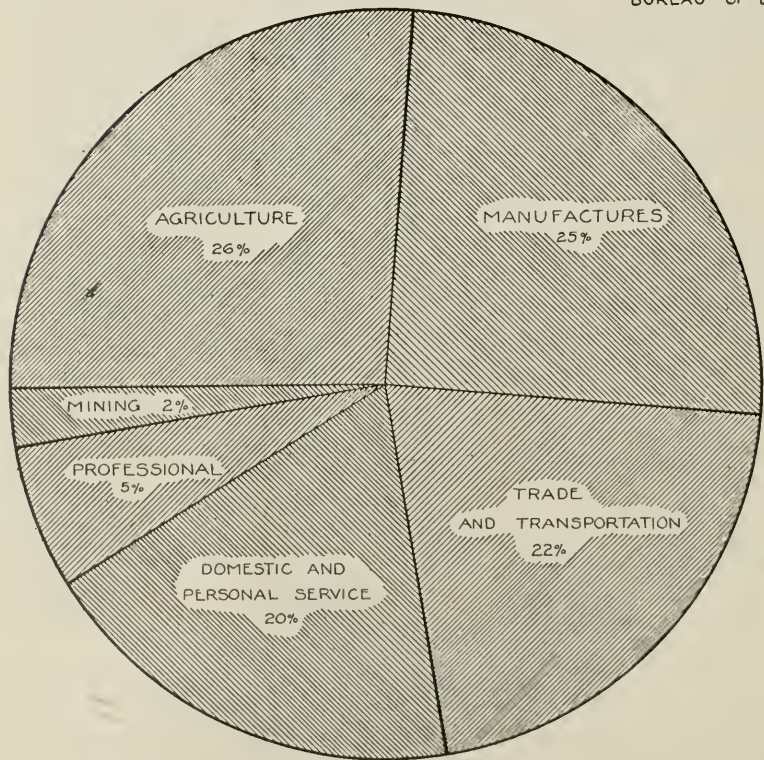


FIG. 5.—DISTRIBUTION OF WAGE EARNERS I NILLINOIS

would seem as though all the wage earners, using all the possible power, were engaged in manufacturing. In these states the value of the manufactured product per capita of population is naturally large. It will be seen, Fig. 7, that in this list of states Illinois stands well

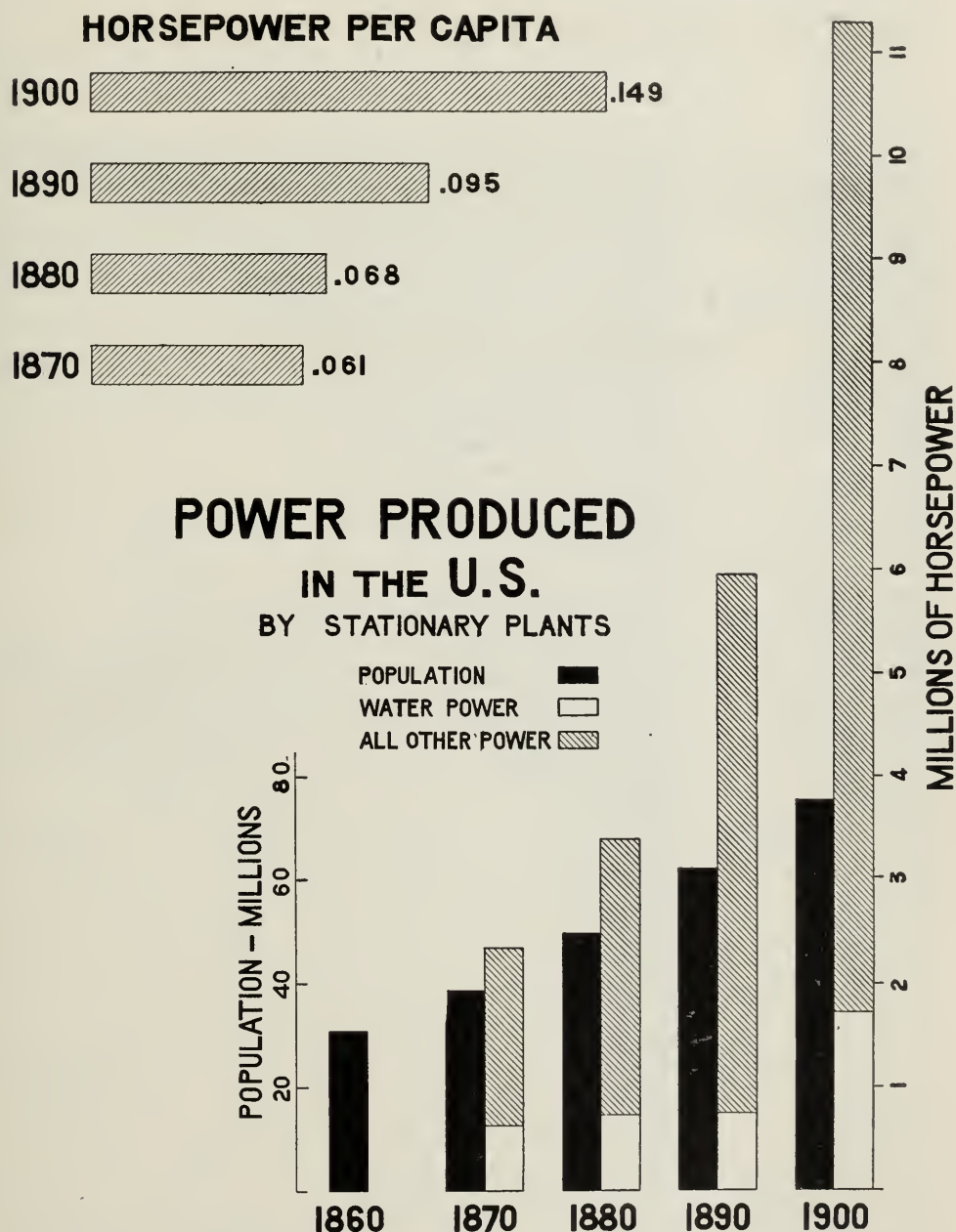


FIG. 6.—GROWTH OF MANUFACTURED POWER

up (eighth), notwithstanding the fact that so many of the wage earners are engaged in agricultural pursuits. The mineral output of Illinois, Table I, is restricted largely to its coal, pig iron, oil, clay, zinc, and other natural stones. Even in this classification the iron

ore is brought into the state, but this method of grouping is usually followed. The subject of its coal production has been so often and so well presented to this Society, that there is no need of treating it at length in this paper. The importance of the generous supply of coal, Fig. 8, furnished from our mines will, however, be of continually increasing importance as time goes on.

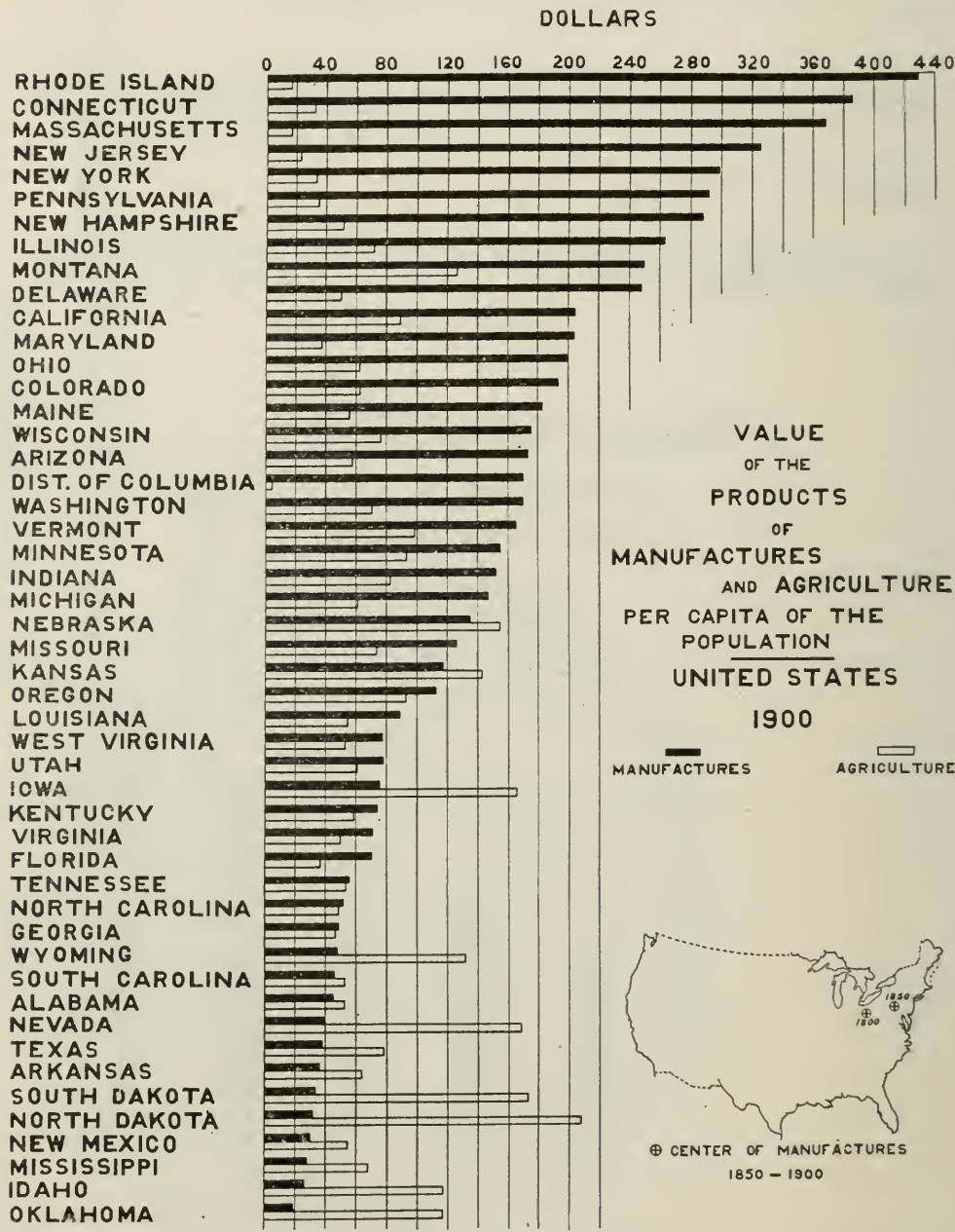


FIG. 7.—PER CAPITA PRODUCTION OF WEALTH

TABLE I.

Total Values of Mineral Output of Illinois in 1906-1907.

	1906	1907
Coal	\$44,763,062	\$54,687,382
Pig iron (estimated)	47,128,000	52,228,000
Oil	3,275,802	16,432,947
Clay	12,783,813	13,351,362
Zinc (estimated)	5,499,508	6,614,608
Limestone	3,476,449	4,333,651
Portland cement	2,461,494	2,632,576
Sand and gravel	1,043,041	1,367,653
Natural and slag cement	188,262	174,282
Fluorspar	160,623	141,971
Mineral water	77,287	91,760
Lead ore (estimated)	45,760	45,760
Sandstone	19,125	14,996
Pyrite		5,700
Total	\$120,922,226	\$152,122,648

The development of Illinois as a manufacturing state is so clearly shown (Fig. 9 and 10) by the table and chart, that nothing need be added in this connection. Since 1850 Illinois has passed twelve states ranking then above it. Whether it can ever hope to reach a higher rank is hard to tell, but it will be many years before it will pass its present leaders, New York and Pennsylvania. The capital invested and the product produced by its thirteen leading industries are matters of some interest (Fig. 11 and 12). Illinois needs next a larger number of smaller factories and it needs to attract a larger variety of industries. It has within itself all the elements which are needed for diversified industries, namely cheap facilities for production—a large population, extensive transportation facilities by lake and rail, and of no less importance it has in Chicago many most extensive and efficient organizations for the distribution of the finished products.

A summary of Illinois manufactures for the two years 1900 and 1905 presents some interesting figures, Table II. It shows the effect of the growth of corporations, the increase in the number of establishments being only 3.8 per cent. In all other items the growth is substantial and rapid.

TABLE II.

Summary of the Manufactures of Illinois.

	1905	1900	Per cent of in- crease.
Number of establishments....	14,921	14,374	3.8
Capital	\$975,844,799	\$732,829,771	33.2
Salaried officials, clerks, etc., number	54,521	40,964	33.1
Salaries	\$60,559,678	\$40,549,245	49.3
Wage-earners, average number	379,436	332,871	14.0
Total wages	\$208,405,468	\$159,104,179	31.0
Men 16 years and over....	314,091	275,006	14.2
Wages	\$187,568,896	\$143,714,217	30.5
Women 16 years and over..	60,399	47,922	26.0
Wages	\$19,893,360	\$13,580,271	46.5
Children under 16 years....	4,946	9,943	50.3
Wages	\$943,212	\$1,809,691	47.9
Miscellaneous expenses.....	\$172,185,567	\$118,047,771	45.9
Cost of materials used.....	\$840,057,316	\$681,450,122	23.3
Value of products, including custom work and repairing.	\$1,410,342,129	\$1,120,868,308	25.8

*Decrease.

The path of the center of population is still advancing westward; a little north of this path, is that of the center of manufacturing which apparently keeps the same few hundred miles behind it, Fig. 13. Recent changes in manufacturing locations for several vast industries will extend those paths still on toward the west. Will these centers reach Illinois? We believe they will and it looks now as though they would finally locate on the campus of the University of Illinois.

The *Engineering Experiment Station* of the University of Illinois was established by action of the Board of Trustees, December 8, 1903, in connection with the College of Engineering.

There were two influences which led to its establishment; first, a demand from the industrial interests of the State for scientific experimentation relating to manufacturing processes, fuel economies and transportation problems; secondly, the very great success attending the work of the Agricultural Experiment Station at the University which made it evident that a similarly successful career ought to be possible for an engineering experiment station. It is very evident from the work which has now been accomplished by our Station and the many helpful things it has done for the industries of the State, that no mistake was made in establishing such a station.

Organization—The control of the Engineering Experiment Station is vested in the heads (9) of the several departments of the College of Engineering. These constitute the Station Staff, and with

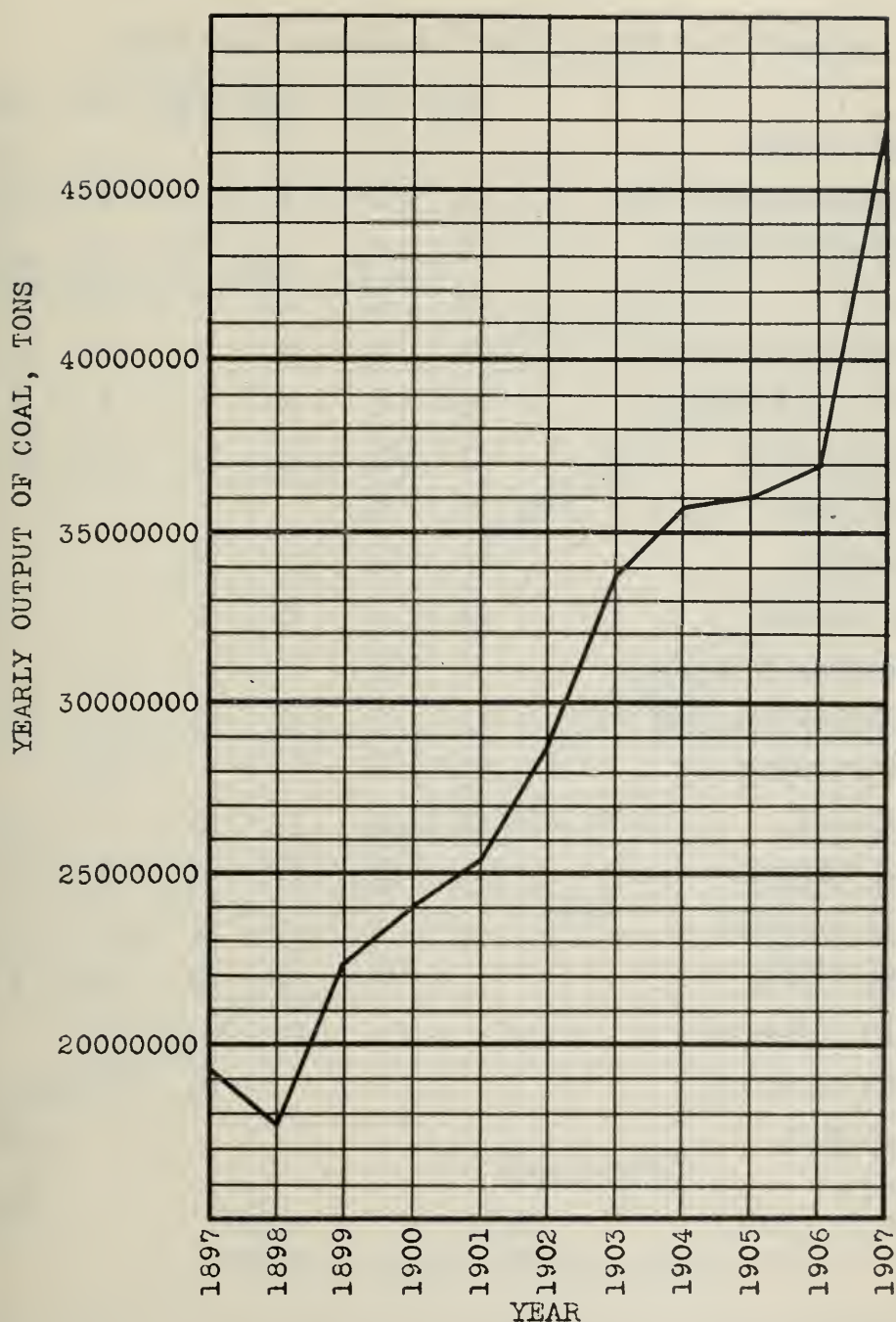


FIG. 8.—YEARLY OUTPUT OF COAL IN ILLINOIS

the Director, determine the character of the investigations to be undertaken. The investigations are carried on by the members of the Staff directly, by fellows as graduate work, by members of the instructional force of the College, and by special investigators belonging to the Station corps.

Plan and Scope—It is the purpose of the Station to carry on investigations along the various lines of engineering, and to make

August, 1909

RANK OF MANUFACTURING STATES.

	1850	1860	1870	1880	1890	1900
NEW YORK	1	1	1	1	1	1
MASSACHUSETTS	2	3	3	3	4	4
PENNSYLVANIA	3	2	2	2	2	2
OHIO	4	4	4	5	5	5
CONNECTICUT	5	5	8	7	10	10
NEW JERSEY	6	6	7	6	6	6
MARYLAND	7	12	14	13	14	13
VIRGINIA	8	9				
MAINE	9	14	12	15		
MISSOURI	10	11	5	8	7	7
NEW HAMPSHIRE	11	15	15			
RHODE ISLAND	12	13	10	14	15	14
KENTUCKY	13				16	
INDIANA	14	10	11	10	11	8
ILLINOIS	15	8	6	4	3	3
CALIFORNIA	16	7	16	12	12	11
MICHIGAN		16	9	9	8	9
WISCONSIN			13	11	9	
MINNESOTA				16	13	12
KANSAS						15
IOWA						16

FIG. 9.—RANK OF STATES IN MANUFACTURING

studies of problems of importance to professional engineers, and to the manufacturing, mining, railway, constructional and industrial interests of the State. It is believed that this experimental work will result in contributions of value to engineering science and to the industries of the State and that the pursuit of such investigations will give inspiration to students and add to the value of the instructional work in the College of Engineering.

Equipment and Facilities—In carrying on the activities of the Engineering Experiment Station, there is necessary a large amount of equipment of various kinds suitable for investigational purposes.

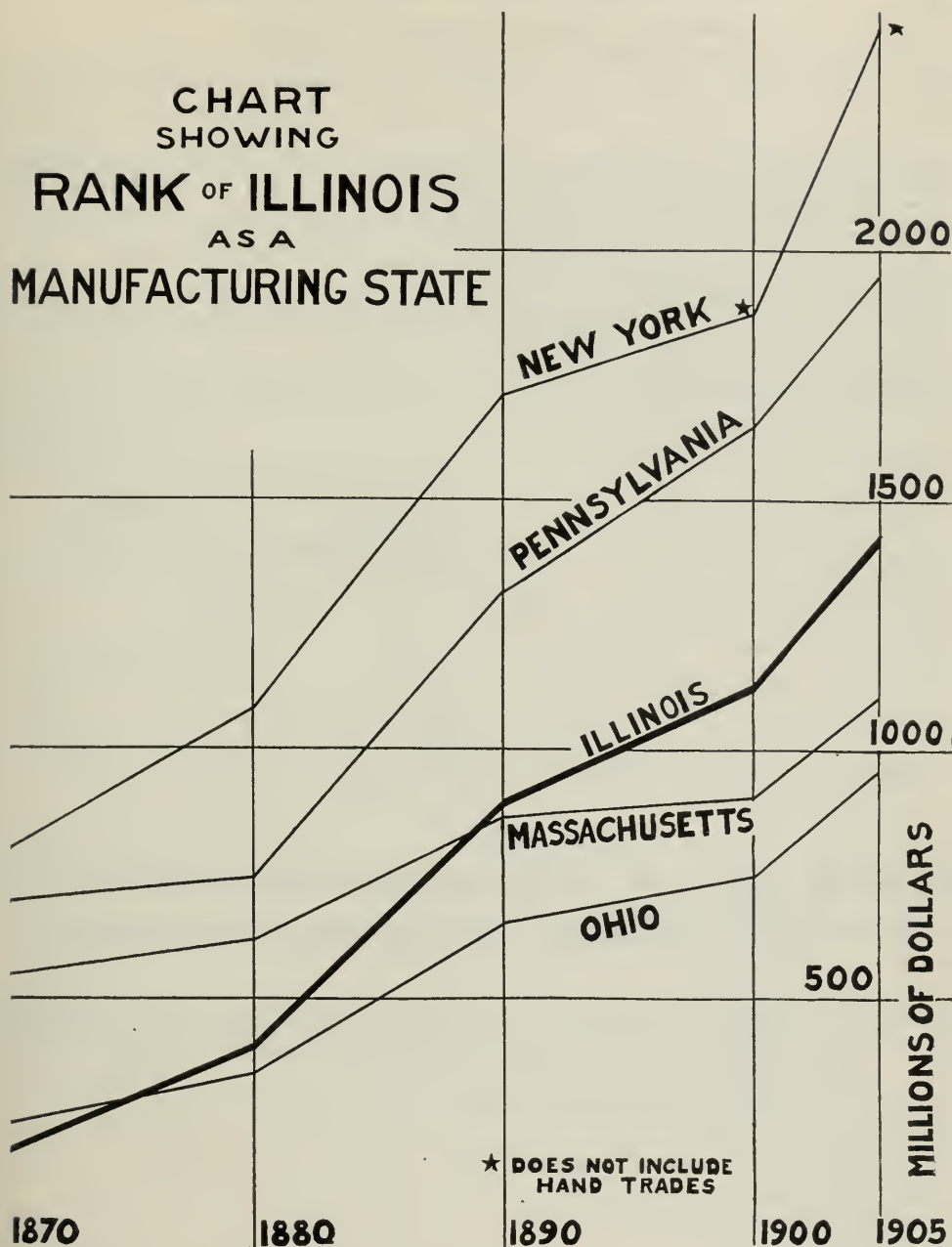


FIG. 10. —RANK OF ILLINOIS AS A MANUFACTURING STATE

The regular equipment provided for instruction in the College of Engineering has largely been used for these investigations, supplemented by the purchase of additional apparatus necessary for special researches in the Engineering Experiment Station. After an investigation has been concluded, the apparatus used becomes a part of the equipment of the department to which it most naturally belongs. The item of expense for equipment, therefore, does not enter into the general expenses of the Engineering Experiment Station. (The value of this total equipment in the College of Engineering is now [April 1909] about \$225,000.)

August, 1909

CAPITAL INVESTED IN THIRTEEN LEADING INDUSTRIES OF THE STATE OF ILLINOIS.

BUREAU OF LABOR STATISTICS-1906

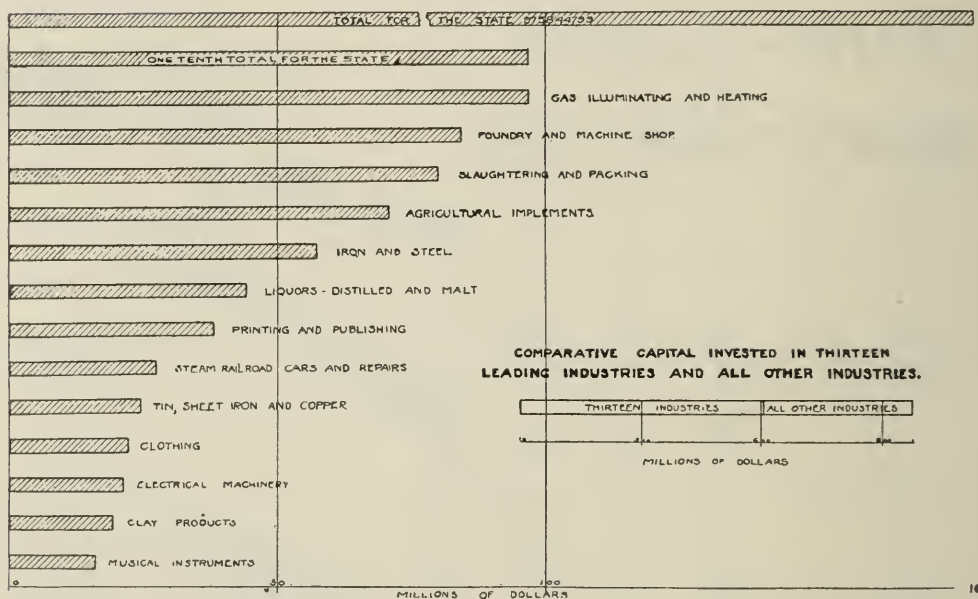


FIG. 11.—CAPITAL INVESTED IN THIRTEEN LEADING ILLINOIS INDUSTRIES

ANNUAL VALUE OF THE MANUFACTURED PRODUCT OF THIRTEEN LEADING INDUSTRIES OF ILLINOIS

BUREAU OF LABOR STATISTICS 1906.

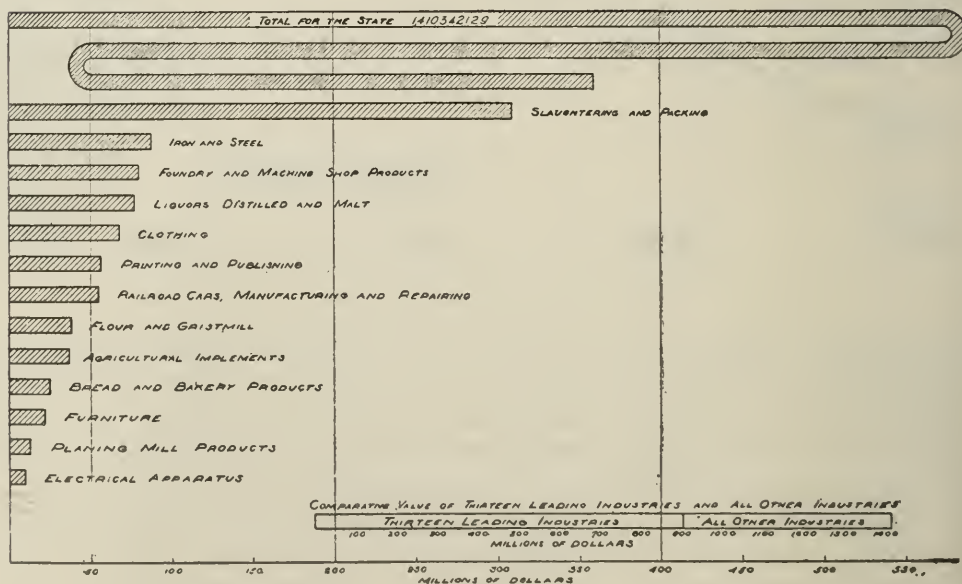


FIG. 12.—ANNUAL VALUE OF MANUFACTURED PRODUCTS IN ILLINOIS

The funds expended in carrying on the investigations, already completed and now in progress, have been during the last five years a little over \$150,000, making an annual expenditure of about \$30,000.

The existence of the Engineering Experiment Station at the University makes it possible to utilize to great advantage—

- (1) The library facilities of the University.
- (2) The continual extension of the equipment of the various departments of the College of Engineering.
- (3) The helpful suggestions and direct co-operation of other scientific departments at the University outside of the College of Engineering.

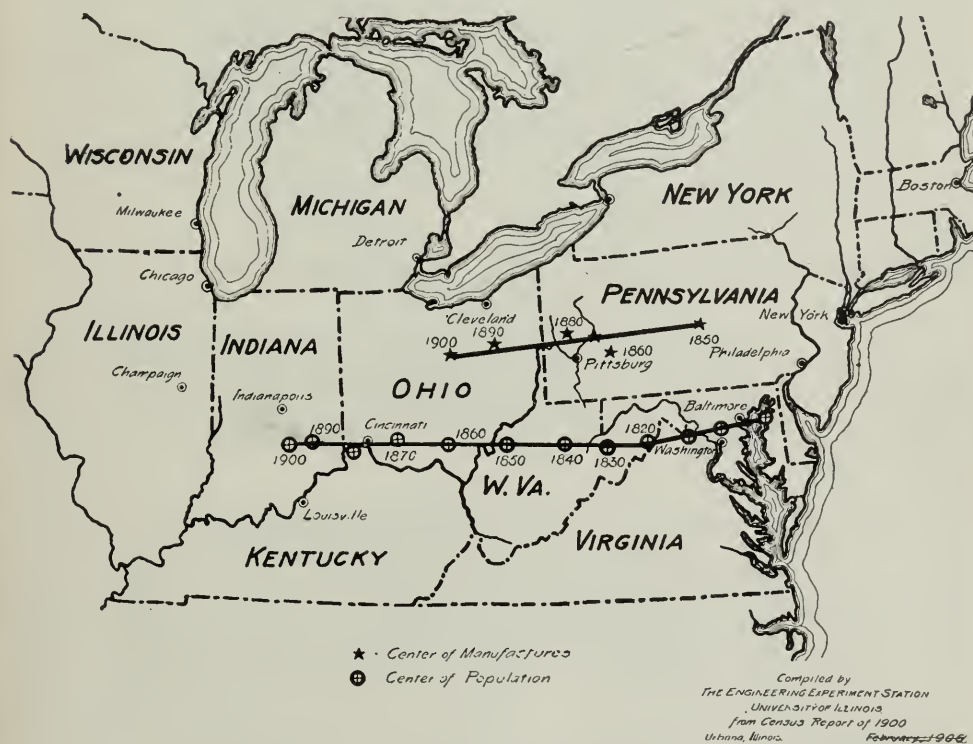


FIG. 13.—PATH OF CENTER OF POPULATION AND OF MANUFACTURES

With these three aids the expenditure of our funds is bound to result in much larger returns than would be possible otherwise.

The work of the Station is going on in all of the technical and scientific laboratories of the University. As an indication of the character of the investigations which are now possible a list of several important pieces of apparatus and installations is given. In connection with this article there are also given several reproductions showing the laboratories in which the investigations are in progress and also the most important apparatus.

LIST OF EQUIPMENT IN THE DIFFERENT LABORATORIES.

In the Laboratories of Applied Mechanics and Hydraulics.

(1) A Riehle vertical screw power testing machine of 600,000 pounds capacity fitted to take large and bulky test specimens. This machine will take compression pieces 25 ft. long and tension pieces

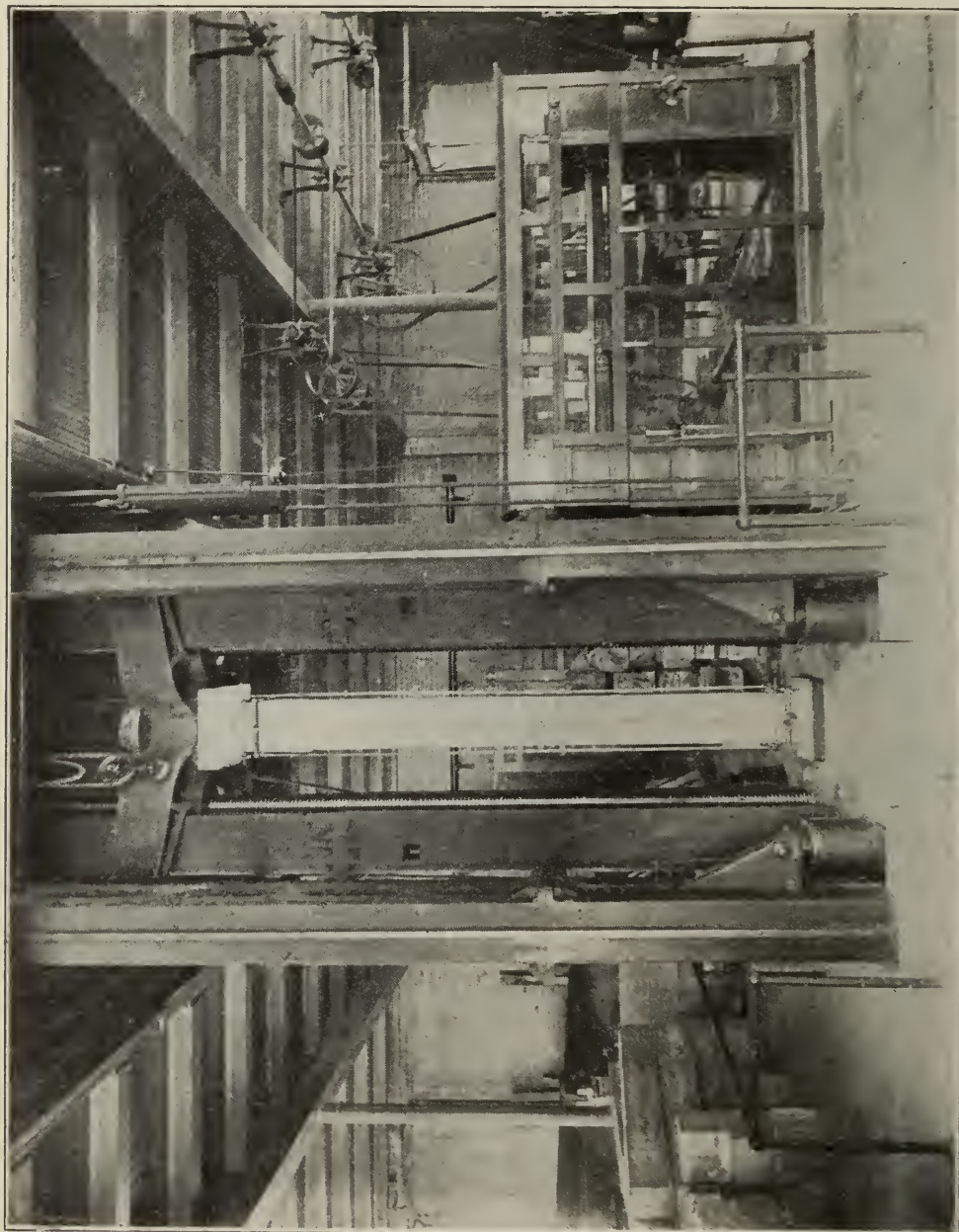


FIG. 14.—TESTING 12 X 12 IN. CONCRETE COLUMN IN 600,000 LB. TESTING MACHINE

of the same net length except as allowance must be made for stretch. The clear distance between screws is 36 in., which gives room for bulky and built-up pieces. The machine is provided with a stiffened vertical frame to allow eccentric and oblique forces to be applied

to test pieces, an unusual feature in testing machines. Short beams may be tested on the machine, and provision may easily be made for testing longer beams. Auxiliary appliances are used for holding the various forms of test pieces in order to secure an application or distribution of the load in the manner desired. Especial attention was given in the design and construction of the machine to making

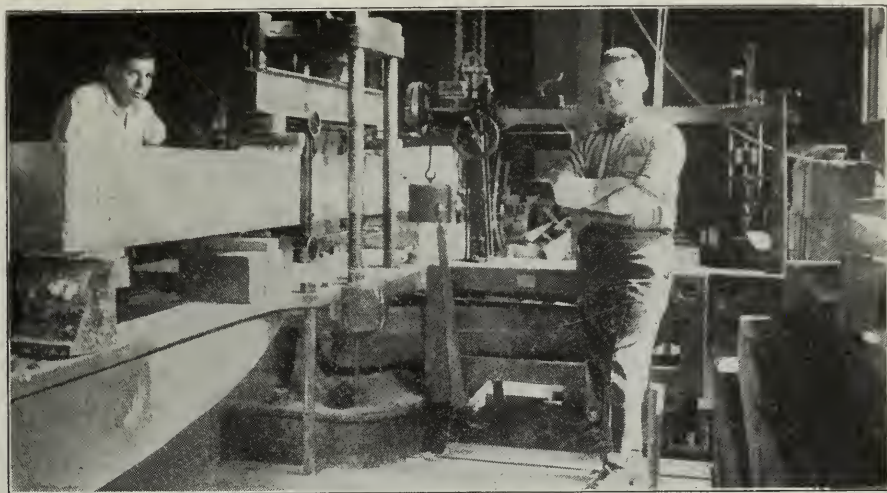


FIG. 15.—TESTING A REINFORCED CONCRETE BEAM

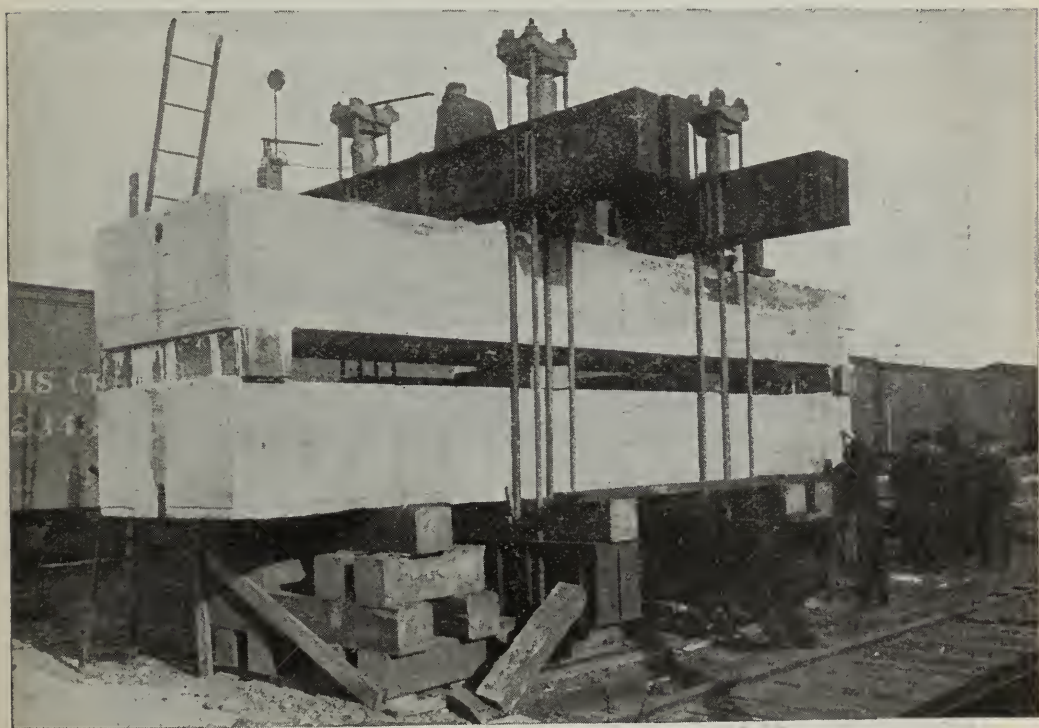


FIG. 16.—TESTING LARGE REINFORCED CONCRETE FLOOR SLABS
FOR TRACK ELEVATION, I. C. R. R.

it applicable to a large range of tests. The calibration of the machine shows that it is very accurate and very sensitive. For the smaller loads a second poise weighing up to 60,000 lb. is used. Fig. 14.



FIG. 17.—TESTING LARGE REINFORCED CONCRETE FLOOR SLABS
I. C. R. R. TRACK ELEVATION

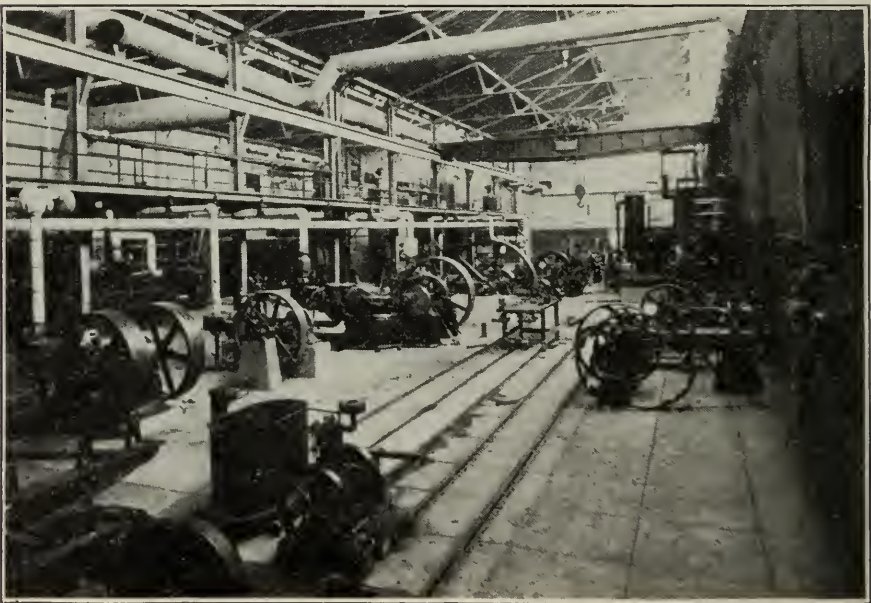


FIG. 18.—GENERAL VIEW OF MECHANICAL ENGINEERING LABORATORY

(2) An Olsen four-screw testing machine of 200,000 lb. for tests in tension, compression and flexure. This machine will take beams up to a length of 20 ft. Fig. 15.

(3) Four 100,000-lb testing machines of different makes, fitted up in the usual way.

(4) An Olsen torsion machine of 220,000 inch-pound capacity.

(5) An Olsen vibratory testing machine for testing stay bolts.

(6) An impact testing machine with a capacity of 3,000 foot pounds, fitted with autographic apparatus for recording the velocity of the falling weight and the deformation of the specimen.

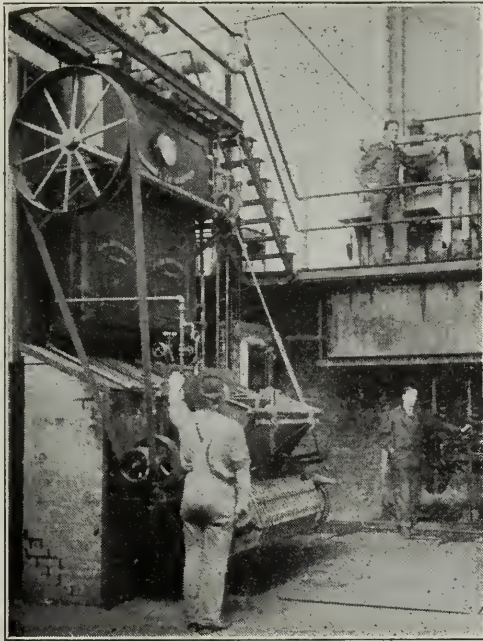


FIG. 19.—EXPERIMENTAL BOILER PLANT, 210 H. P. HEINE WATER TUBE BOILER
GREEN CHAIN GRATE, STURTEVANT ECONOMIZER AND FOSTER SUPERHEATER

(7) Four hydraulic jacks with pumps having a total capacity of 800,000 lb., with auxiliary rigging, available for testing large culvert pipe, large reinforced concrete beams, reinforced concrete pier footings and other bulky pieces. Fig. 16 and 17.

(8) A variety of smaller machines for testing cast iron, timber, etc.

(9) A large equipment in measuring devices such as extensometers for various uses, autographic recording devices, gauges, etc. Many of these pieces of apparatus were designed and built by the department and are especially adapted to the work of the laboratory.

(10) A commodious hydraulic laboratory, well equipped with steam engine, steam pumps, centrifugal pumps, standpipe and pressure tanks, lines of piping, measuring pits, tanks, weirs, gauges, meters, motors, etc., giving excellent facilities for testing hydraulic apparatus and for making investigations in hydraulics. The equipment includes apparatus for the study of problems of sedimentation and filtration of public water supplies and the softening and removal of iron from water.

In the Mechanical Laboratory.—(Fig. 18 and 19.)

1. A 210 H.P. Heine water-tube boiler especially arranged for testing Illinois coals. This boiler is a duplicate of the boilers used by the United States government in testing coals from various parts of the country. A Green chain grate stoker is installed under this

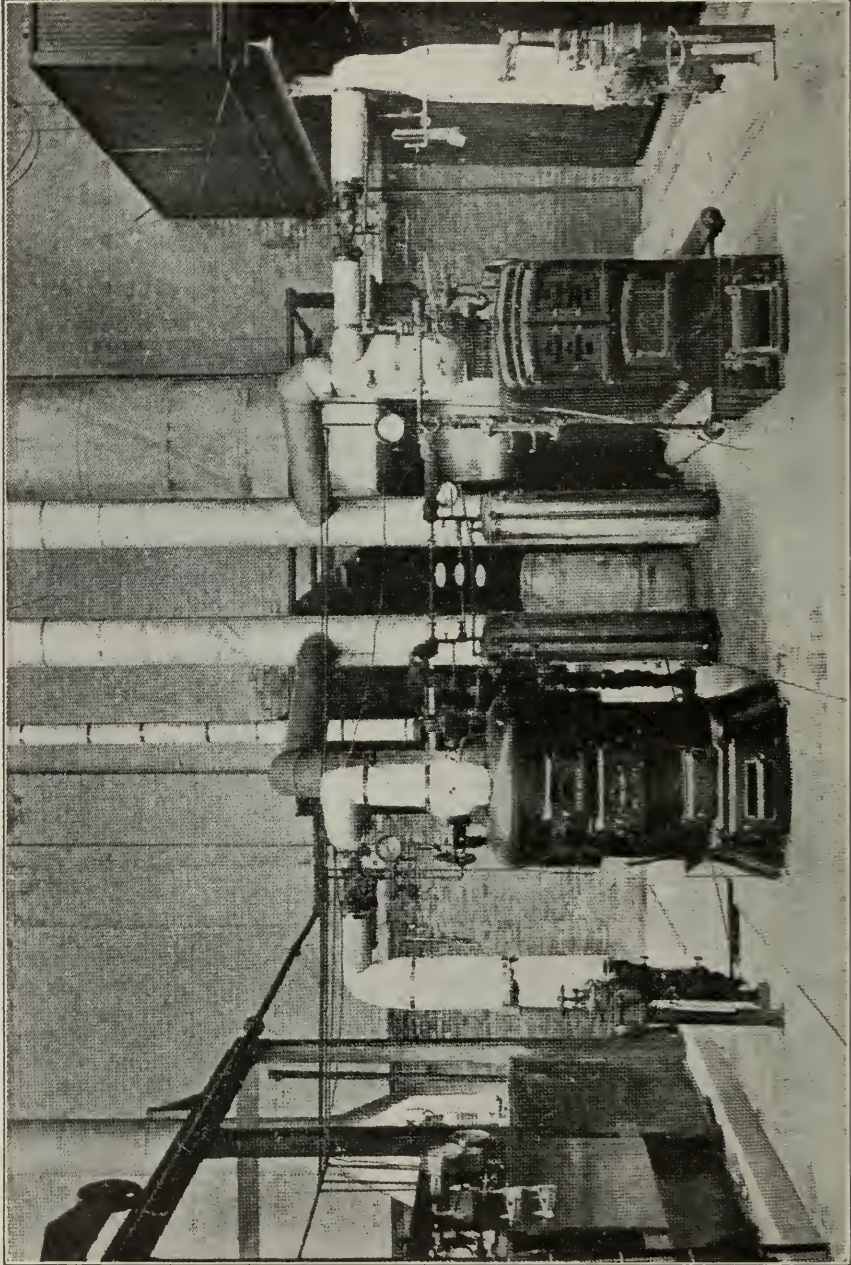


FIG. 20.—HOUSE HEATING BOILERS, TESTING FLOOR

boiler, and draft is furnished by a Sturtevant induced draft fan, drawing the gases through an economizer. The chain grate under the boiler may easily be removed and a plain furnace for hand-firing substituted. A complete equipment of auxiliary apparatus

necessary for boiler tests is available, including recording and optical pyrometers, and standard and recording apparatus for continuous gas analysis. Facilities are now available in the department of physics for calibrating all thermometers and pyrometers used in work of this character.

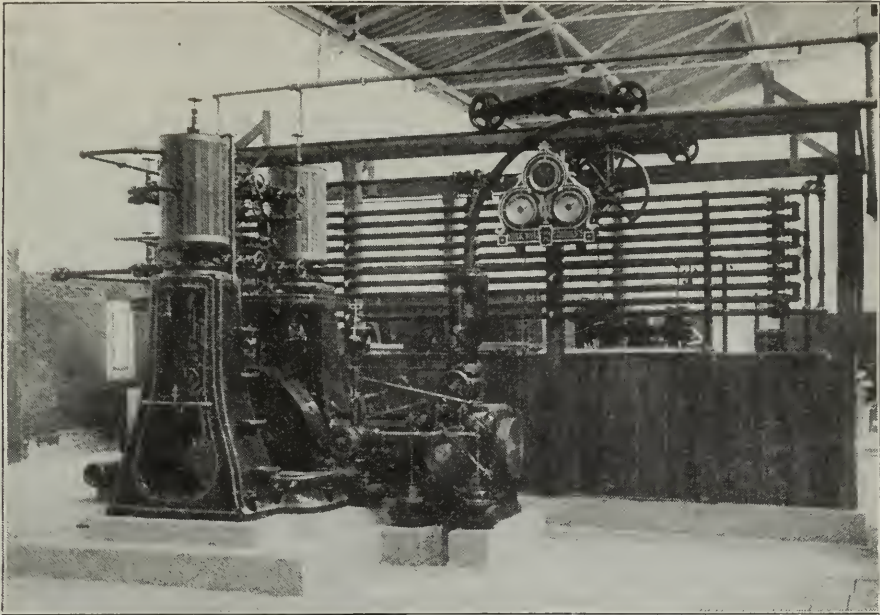


FIG. 21.—YORK ICE AND REFRIGERATING MACHINE

2. An independently-fired Foster superheater capable of superheating the steam from a 150 H.P. boiler to 300 deg. F. above its temperature, at 120 pounds gauge.

3. Several residence heating boilers, for hot-air, steam and hot water service. These boilers will serve to compare the values of such various coals as are offered in the Illinois market for domestic purposes. Fig. 20.

4. A 10-ton York refrigerating plant for the production of cold or for specific tests. With this plant there are 17 cans for ice making, each holding 100 pounds. The possibility of subjecting various building stones or other material to alternate freezing and thawing is worthy of consideration. The effect of fifty winters might thus be known in a single month. The heat conductivity of all kinds of walls used in buildings could be tested. Fig. 21.

5. A liquid air plant with a capacity of about three quarts an hour. It consists of a Norwalk four-stage compressor, compressing up to 3,000 pounds, together with a Hampson liquefier with facilities for temperature determinations.

6. An Ingersoll-Sergeant two-stage air compressor driven by compound steam cylinders. The steam cylinders are 12 in. and 22 in. in diameter with a 12 in. stroke, and air cylinders are 12¼ in.

and 18 $\frac{1}{4}$ in. in diameter with a 12 in. stroke. A vertical receiver 42 in. by 8 ft. high is provided for use with the compressor.

7. A 50 H.P. suction gas producer built by the Otto Gas Engine Works. This producer is adapted to burning anthracite pea coal, coke or charcoal. Special apparatus is available for extensive investigations of gas producer problems.

8. An Otto gas engine of 23 H.P. capacity for use in connection with the gas producer. The engine cylinder is 10 in. in diameter, with a 19-in. stroke. It is provided with a compressed air starting device, sparking generator, speed indicators and all other instruments necessary for testing gas engines. Fig. 22.



FIG. 22.—A 50 H. P. GAS PRODUCER AND OTTO GAS ENGINE
IN MECHANICAL ENGINEERING LABORATORY,

9. A 15 H.P. De Laval steam turbine direct-connected to a compound centrifugal pump. This apparatus will deliver 140 gallons of water per minute when pumping against a head of 500 feet. The turbine wheel and small pump runner make 23,500 revolutions per minute; the large pump runner makes 2,350 revolutions per minute. The turbine is provided with condensing and non-condensing nozzles.

10. A hot blast heating system installed to heat the Mechanical Engineering Laboratory. This consists of a series of coils amounting to 2,800 feet of 1-in. pipe and a 72-in. fan draws the air through the coils and forces it into the galvanized iron pipe, 36 in. in diameter, which distributes it to different parts of the building. The fan is driven by a small vertical steam engine.

11. A 100 H.P. Allis-Chalmers Corliss engine, equipped with a suitable brake and other apparatus for making tests.

12. Several high-speed steam engines for testing and for driving other apparatus.

13. Several types of gasoline engines, ranging from 1 to 10 H.P., for experimental purposes.

14. Automobile motor, 4 cylinder, independently cast, of 30 H.P., specially equipped for extensive investigation of high-speed internal combustion motors.

15. An automobile testing platform for testing automobiles.

16. A six-stage, 60 H.P. Kerr steam turbine, equipped with absorption dynamometer, and installed with 60 H.P. Wheeler surface condenser and supplied with saturated or superheated steam.

17. A Worthington surface condenser, 362 sq. ft. of cooling surface with independent steam driven vacuum and circulating pumps, equipped for special investigations of condenser performance.

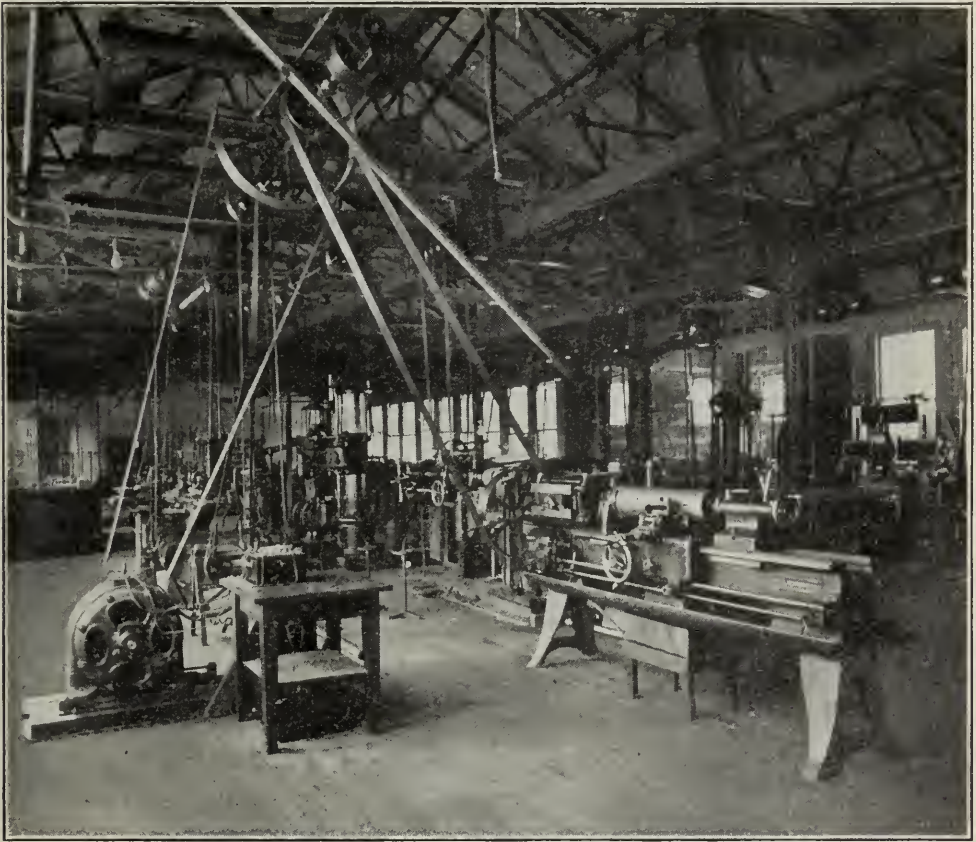


FIG. 23.—U. OF I. MACHINE SHOP, LATHE AND MOTOR DRIVE FOR TESTS OF HIGH SPEED TOOL STEELS

18. A Meitz & Weiss, 2-cycle, 10 H.P. kerosene engine equipped for comparative tests of oil and alcohol.

19. Gas Analysis Laboratory for complete analyses of flue gases from Heine boiler and house heating-boilers and furnaces, exhaust gases from gas engines, and power gas from the producer.

20. A 10-ton electric crane, having three alternating current motors, for experimental work.

21. A Golden oil testing machine for testing lubricating oils and bearing metals.

22. A lathe and motor for tests with high speed tool steels. Fig. 23.

In the Electrical Laboratory—(Fig. 24).

1. Three rotary converters furnishing current based on 110 and 550 volts D. C.
2. A 15 H.P. variable speed Westinghouse D. C. interpole motor giving a speed range of 300 to 1,200 rev. per min.
3. A 7½ kw. inductor alternator which can be run at frequencies up to 150 cycles.

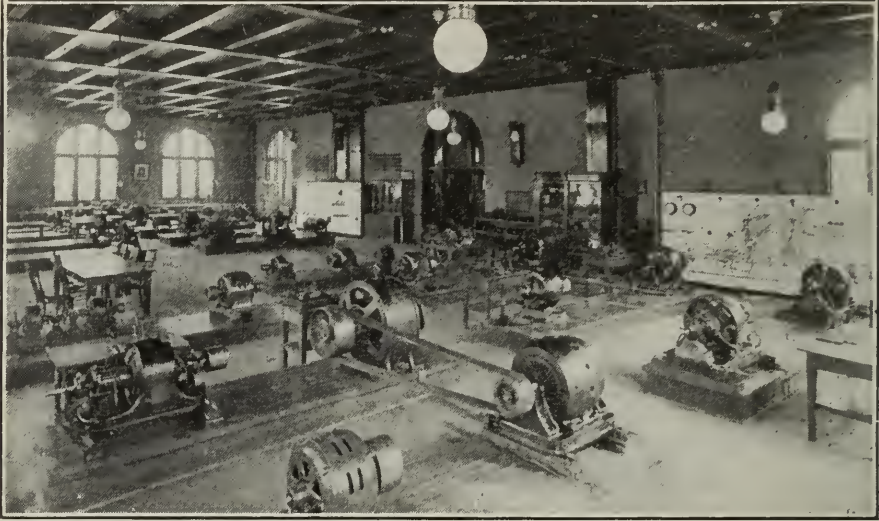


FIG 24.—MAIN TESTING FLOOR OF THE ELECTRICAL LABORATORY

4. Two General Electric stationary armature alternators designed to operate as either two or three phase generators or motors and at a variety of voltages.
5. A 45 kw. motor generator set, used to furnish a constant voltage either A. C. or D. C. for experimental purposes.
6. Several induction motors ranging from 2 to 5 H.P., of one, two, and three phases and various voltages.
7. A number of 110 and 220 volt D. C. motors of from 10-15 H.P. and a variety of D. C. generators of various makes and ranging up to 10 kw. in capacity.
8. A single phase, variable speed, 220 volt, 10 H.P., A. C. motor.
9. A 60 cell Gould storage battery of 240 ampere-hours capacity with a switch board so arranged that all voltages between 2 and 120 can be obtained; also current up to 100 amperes at full voltage with greatly increased current at lower voltage.
10. A large number of transformers of various capacities, voltages and transformation ratios, including a small 10,000 volt and a 10 kw. 100,000 volt testing transformer.
11. A photometry and illumination laboratory, provided with a

3 meter and a 5 meter photometer bar, photometers of various kinds, standard lamps, a Sharp Millar illuminometer and a room equipped for the study of problems in illumination.

12. Two experimental telephone switchboards and a supply of both manual and automatic telephone apparatus.

13. A large equipment in electrical measuring instruments of various types, both A. C. and D. C., among which is a series of electrostatic voltmeters measuring up to 1,800 volts.

14. A fine set of standard electrical measuring instruments including a Weston D. C. laboratory standard voltmeter and a millivoltmeter, Westinghouse precision voltmeter, ammeter and wattmeter and a Leeds Northrup potentiometer.

There are also switchboards for rapid handling of apparatus, numerous lamp banks for resistance, oscillographs, inductances, condensers, a mercury arc rectifier, arc lamps of many types, racks for life tests of incandescent lamps and much other smaller apparatus of value in research work. The department maintains a well equipped machine shop with an expert mechanic in charge so that special apparatus can be made under the direction of the experimenter on short notice.

The Cement Laboratory.

This laboratory is equipped with briquette molds, molding machines, testing machines, etc., necessary in testing hydraulic cement, and in making investigations as to the effect of different materials and methods of manipulation upon the strength of mortars and concrete.

The Road-Materials Laboratory—(Fig. 25).

The Civil Engineering department in its Road-Materials Laboratory is equipped with apparatus for testing materials for road and pavement construction as follows:

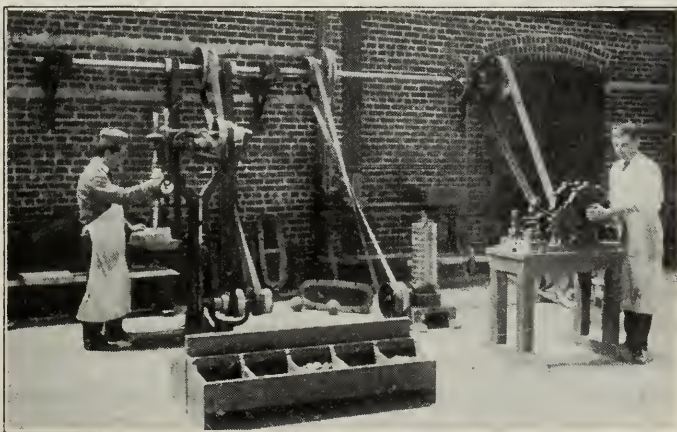


FIG. 25.—ROAD MATERIALS TESTING LABORATORY

(1) Two types of rattlers for testing brick: National Brick Manufacturers' Association and Talbot-Jones, machines.

(2) A Dorrey, a Deval and a Page machine with the necessary accessories for testing the road-building qualities of gravel and macadam.

(3) A stone crusher, ball mill, briquette machine and impact machine for testing the cementation of stone and gravel for road construction.

(4) Testing sieves and agitator for grading stone and gravel, also balances for accurate weighing.

In the Physics Laboratory.

The department of Physics has already done much valuable work for the Engineering Experiment Station. Upon the completion next September (1909) of its new Physics Laboratory, costing a quarter of a million dollars, it will then have such equipment and facilities as will enable it to do extensive fundamental research work which will be of great value to the Station. It is already well equipped for such work as—

(1) The checking and calibration of instruments for measuring temperatures.

(2) The checking and calibration of electrical standards and instruments.

Miscellaneous Testing.—Besides the equipment for the work in the lines indicated above, the department of Physics is supplied for research work with standard apparatus of a variety of kinds, all of which is available for testing purposes. Such facilities are standard barometers, standards of length, photometric standards with photometers, standards of weight with sensitive physical balances, a dividing engine and comparator, vacuum and compression pumps with gauges, and various optical apparatus for the determination of optical constants and accurate appliances for the measurement of volume or pressure of liquids and gases.

In the Railway Laboratory.

(1) *Electric Test Car.*—The Railway Engineering Department owns a two hundred horse power electric test car. This car, of the interurban type, was designed especially for experimental work and was built in 1905. It is equipped with four-50 H.P. D. C. motors and with the Westinghouse multiple control system. The car is supplied with recording voltmeters, ammeters, and wattmeters and with auxiliary measuring and recording devices by means of which there is automatically made a graphical record of voltage, current, power, speed, acceleration, time, and curvature.

By the courtesy of the Illinois Traction System, whose lines are at present operated between the cities of Danville, Urbana, Champaign, Decatur, Bloomington, Springfield and St. Louis, the department is enabled to operate this car on their lines.

(2) *Dynamometer Car.*—There was designed and built in 1900 a dynamometer car which is owned jointly by the University and the Illinois Central Railroad. This car is equipped with all the appliances necessary for carrying on train resistance experiments, as well as with auxiliary apparatus used during locomotive tests. During the seven years in which it has been in service this car has been operated over the entire Illinois Central System, in the establishment of tonnage ratings, as well as on the lines of the New Jersey Central, the Baltimore and Ohio, the Cleveland, Cincinnati, Chicago and St. Louis, and the New York Central Railways. Fig. 26 is a view of the interior of this car.



FIG. 26.—INTERIOR OF DYNAMOMETER CAR

(3) *Drop Testing Machine.*—There has recently been added to the equipment of the Railway Engineering Department a standard drop testing machine which in its design conforms to the specifications of the Master Car Builders' Association. This apparatus is used in making impact tests of car couplers, wheels, axles and other material. It consists essentially of a hammer weighing 1640 pounds which runs in vertical guides fifty feet in height. The material to be tested is placed upon the massive foundation at the base of the machine and the hammer is allowed to fall upon it from any desired height.

(4) *Brake Shoe Testing Machine.*—For the testing of brake shoes the department has constructed a brake shoe testing machine similar in design and identical in operation with the standard machine owned by the Master Car Builders' Association. By means of this apparatus it is possible to determine the coefficients of friction and the wearing qualities of various makes of brake shoes, as well as the wear of the wheel under the action of the shoes.

The above list will serve to show what facilities are now available for investigations in certain lines of work; but after all it is *men* and not facilities that determine what of value will finally be done. The men who have been giving thought, direction, energy and work to the Station during the last year are in a general way indicated by the following groups:—

- (a) The heads of the different departments of the College of Engineering..... 9 persons
- (b) The special investigators of the Station. Experts devoting all their time to this work, doing work, directing work and planning work..... 9 persons
- (c) Research Fellows of the Station appointed for two years, devoting one half their time to the investigations of the Station and one half to Graduate Work, receiving the Master's degree at the end of the period..... 9 persons
- (d) Various members of the corps of instruction of the College of Engineering who are able to devote a small part of their time to some investigation or who are able to direct some work in progress by assistants, fellows or scholars.. 10 persons
- (e) Some Fellows and Scholars doing research work in the Graduate School..... 4 persons
- (f) Heads of other departments of the University. Experts of the Federal Government, chiefs of state department bureaus, all cooperating with the Station for the mutual advance of special investigations 8 persons
- (g) Advisory Committees representing various engineering societies and commercial and civic organizations giving counsel, advice, suggestions and criticisms 10 persons
- (h) Draftsmen, computers, clerks, mechanics, assistants and laborers 12 persons

It will thus be seen that more than seventy persons are now more or less directly interested in the work of the Station; of this number about fifty are actively engaged in the work of the Station for a part of their time and approximately twenty persons are devoting all their time to the interests of the Station.

The Work Already Accomplished.

The work which has thus far been undertaken may be divided into three parts:—

- (a) Work completed and results published.
- (b) Work in progress.
- (c) Work of preliminary investigations.

(a) There have now been published (a few now in press) thirty-six (36) bulletins of the Station. As these bulletins are sent to all members of this Society it will not be necessary to refer in detail to their titles or to the character of the investigations to which they refer. When an investigation has been completed and the manuscript and drawings are ready for the press, a publication committee of three is appointed who are asked to read the material prepared, to look out for errors, and to criticise the work as they desire. The number of each edition published varies from six to twelve thousand copies, depending upon the character of the work and the estimated demand for the number. In several instances a second edition has been found necessary. At present about one-half of the bulletins printed are sent to residents of Illinois, the other half are sent to residents of other states and foreign countries. That the work of the Station is fully appreciated by engineers, manufacturers and others is shown by the hundreds of congratulatory letters received by the Station as well as by the very considerable space given in the best technical papers at home and abroad, to the reproduction of its papers and to favorable editorial comment. It is particularly desired that the bulletins of the Station should be received by all persons in Illinois interested in the numerous problems which connect its many industrial activities with the researches of engineering and applied science, such as manufacturing, mining and railway transportation; the chemical and heat values of Illinois fuels; coal consumption in boiler furnaces, in gas producers, or in residence heating furnaces; the strength of materials used in building engineering structures; the strength of concrete both plain and reinforced; the durability of road material; the flow of water in pipes, conduits and channels; the sanitary problems of industrial corporations and municipalities; the generation, transmission and use of electricity; the problems of architectural construction, roof trusses, columns, base plates, piers and foundations; the cost of power and the problems of heating and ventilation; the problems of heat transmission, radiation and absorption; the problems of speech and signal transmission and many other problems which the above enumeration will suggest.

In the wise distribution of the publications of the Station, the members of this Society may be most helpful and they should request that bulletins be sent to such persons, particularly those living in Illinois, as they believe would use and appreciate them. There are in Illinois about one hundred and fifty public libraries, all of

which receive our bulletins. They should be urged to preserve their copies, as many of the earlier numbers are now out of print and are not easily procured.

The mailing list for the Experiment Station bulletins is made up about as follows:—

1. *Receiving All Bulletins.* (a) List comprising all members of the W. S. E.; (b) All members of several Illinois societies, clubs and commercial organizations; (c) The residents of Illinois who are members of the National Engineering Societies; (d) The Technical Press, domestic and foreign; (e) The leading libraries of the U. S. and all libraries in Illinois; (f) Instructional Staff and all graduates of the College of Engineering..... 4500
2. *Receiving only Classified Bulletins.* (a) Manufacturers interested only in special subjects; (b) Fuel Engineers; (c) Refrigeration engineers; (d) Heating and Ventilating Engineers; (e) Railway Clubs; Boards of health; (f) City Smoke Departments; (g) Schools and Colleges; (h) Miners and operators of Coal Mines.....1000 to 4000
3. *Receiving Bulletins on Request.* (Application for Bulletins reach the Station from all parts of the world following reviews by the technical press).....1000 to 1500
4. *Unclassified List—General* 500

(b) There are now over fifty lines of investigation in progress in the Station; some are nearing completion, some are but just started. Many preliminary researches reveal the absence of any necessity for further work. Some investigations lead only to negative results. The following list will give an indication as to the character of work now (May 1, 1909) in progress, distributed among the various departments.

Investigations in Progress.

1. A study of plain base plates and ribbed base plates for columns.
2. Economical design of steel and of wooden roof trusses.
3. Description of specialties and conveniences adapted for isolated country dwellings.
4. Tests on the action of rolling loads on ordinary highway bridges.
5. Standardization of the rattler test for paving brick.
6. Use of concrete on the farm.
7. Tests on tungsten lamps.
8. Interference between high potential and telephone lines.
9. Tests of household electric appliances.

10. Electric drives for machine tools.
11. The flow of steam through nozzles.
12. Transmission of heat through tubes under varying velocities of water flow.
13. Gas producer tests at varying capacities.
14. Problems in steam heating by a central station system.
15. The cost of power.
16. Fuel tests with house-heating boilers.
17. Experiments on a smokeless furnace.
18. Fuel tests with hot air furnaces.
19. Fuel tests with Illinois coal in power plant boilers.
20. The weathering of coal.
21. Causes which promote the spontaneous combustion of coal.
22. Report of tests of Illinois Coals by U. S. Geol. Survey.
23. Occluded gases in coal.
24. The low temperature distillation of coal.
25. On the rate of formation of carbon monoxide in gas producers.
26. Thermal-conductivities at high temperatures.
27. Boiler waters.
28. Electric car resistance.
29. Boiler plate temperatures.
30. Wheel flange pressures.
31. Tests of rock ballast road-beds.
32. Resistance of interurban cars on curves.
33. Train resistance tests on steam roads.
34. Relation of economic conditions of territory to types of electric roads.
35. The properties of reinforced concrete columns with special reference to the use of large amounts of steel.
36. The properties of reinforced concrete beams; web resistance and modulus of elasticity.
37. Reinforced concrete wall footings and pier footings.
38. An investigation of continuous beams made with reinforced concrete.
39. Bond between concrete and steel.
40. The distribution of stress in structural steel columns.
41. A study of tests of timber stringers.
42. The distribution of stresses in structural steel compression pieces.
43. The action of metals under torsional and under combined flexure and torsion.
44. Resilience of metals beyond the elastic limit.
45. Strength and cost of acetylene-oxygen welds in steel and other metals.
46. Flow of water through sand and well screens.
47. The discharge of water from orifices and short tubes.
48. An investigation of water hammer in pipes.

49. Measurement of water by means of vertical tubes.

Doubtless some of the above work will lead to no results, some of it will not be completed for several years to come, but much of it is progressing rapidly and the prospect is good for future valuable bulletins covering a wide field.

The Influence of the Station on Our Educational Work.

It was our thought at the outset that the pursuit of definite experimental work would give inspiration to our students and add to the value of the instructional work of the College of Engineering. We have found this to be true. The work of the Station has had a marked effect in strengthening our instructional work. The contact with scientific experimentation and the methods of presenting the results in carefully prepared bulletins is a most helpful factor in the training of the young engineer. It is impossible for our experimental work to go on without attracting the attention of our students. The work must be carefully and accurately done; the preparation of charts and diagrams and the checking and re-checking of results and computations involve extreme care and accuracy. The fact that students see how problems are taken up, how they are solved, and the whole work satisfactorily presented, is perhaps the greatest single educational gain to them. They live in an atmosphere of research which they unconsciously absorb. They are attracted toward research work themselves. They realize that failure to contribute each particular assignment with accuracy may result in the failure of the entire experiment. While the investigations are carried on by the experts of the Station, still there is abundant opportunity to make real use of student help in many tests and computations. The chance to participate in many of the tests is appreciated and eagerly sought by the students. They are interested in the direct application of theoretical principles to the solution of practical, every day engineering problems. This illustrates the old pedagogical principle that when students are permitted to take part in real activities, they are more alert, interested and accurate than when merely carrying on exercise tests.

Some institutions have recently dropped the thesis requirement. This appears to be an unfortunate move. It has probably been caused by large classes and insufficient help and facilities. In the work of this Station many subjects relating to researches in progress are capable of preliminary investigations as thesis work, and students pursue this work with unusual care and attention. Students are also greatly benefited by conferences with and lectures by our special investigators who are always in readiness to advise students along the line of their particular problems.

Encouragement and aid are freely given to members of the instructional force who desire to take up some line of research. In this way much excellent work is done which necessarily reacts on

the quality of class instruction, and at the same time proves a source of development and broadening. This work serves to keep us all in close touch with outside engineering interests and practical every day problems in the industrial world. While our bulletins record mostly the results of the Station's own staff of investigators, there is also the publication of circulars, giving compilations of the results of important experiments by engineers, industrial works, technical institutions and governmental testing departments. This opens up opportunities for our instructors who can not undertake purely experimental work.

Each head of a department in the College of Engineering, being an active member of the Station Staff, is constantly on the alert to detect the possibilities of important lines of work and also to study the adaptation of certain men to certain lines of work and to the possibility of developing investigators from our present body of students and instructional force. While it may be true that the genuine investigator and experimenter, like the poet, is born and not made, still much may be done to develop the spirit of investigation. This in itself is always an element of true teaching and the awakening of a more general spirit of investigation would undoubtedly be an element of strength in all our educational work.

Research Fellowships.

The facilities of the Station for research have made it possible to do real graduate work, and the action of the trustees in providing for ten research fellowships in the College of Engineering of an annual value of \$500 will be a distinct gain to advanced engineering education. The rapid growth of the Graduate School of the University is also proving most helpful to the interests of the Engineering Experiment Station and an increasing number of scholarships and fellowships in this department is to be expected.

Future Work of the Station.

In determining the character of the work which the Station shall undertake, the most careful consideration must be given first to the needs and the interests of the state of Illinois. Fortunately Illinois is singularly favored in all the conditions requisite for a rapid and permanent industrial development, and its interests cover very wide fields of engineering activity. In view of its cheap and abundant fuel, its great agricultural wealth and its unexcelled facilities for the transportation of raw material and finished products, it is not surprising that Illinois is the second state in the union in agriculture and third in manufactures. With these great resources devolves upon us great responsibility in developing and husbanding them. The testing of its materials of construction will always be a matter of importance for any state. The prevention of the waste of ma-

terial growing more and more expensive, as wood, and the correct factors of strength of new materials, as concrete, are always subjects for the most careful investigation. To this work we are giving considerable attention, and the demand for the results of our tests on reinforced concrete which are being carried on under the supervision of Professor A. N. Talbot indicates the interest which is taken in this work and the necessity felt by architects, constructors and builders for the most exact information along these lines.

The work of the Station will also extend into some fresh fields, seeking to discover new ways and means for economizing energy and materials, for the prevention of waste, for the protection of labor-saving machinery, for safer methods of travel, and for surer sanitary methods of water supply and sewage disposal.

Fuel supply is of such prime importance in our industrial development that no effort should be spared in the introduction and promulgation of improved methods and processes in the mining, preparation and consumption of coal. From broad economical considerations wasteful methods of using coal, or the rejection of any combustile part as waste, are to be discountenanced. Exhaustive and careful experiments will be required before the best conditions can be attained. These experiments must include analyses of coals from all parts of the state, a determination of the best kinds of coal for specific purposes, best methods of burning Illinois coals, effects of various methods of preparation, experiments on various kinds of furnace construction, etc.

Along the line of power production there is opportunity for much investigation. New problems are confronting both the builders and users of steam and gas motors. There is at present a noteworthy change from the reciprocating engine of large size to the steam turbine. Gas engines of large power have recently been installed, and the development of this type of motor bids fair to be more rapid in the near future. Still newer types of motors are being proposed from time to time, the gas turbine being one that at present occupies much attention as an attractive possibility.

For the user of power, the Station can investigate questions relative to the economy of various types of power installations with given conditions of service. For the builders of motors it can investigate the new and perplexing problems that have arisen. The properties of the various fluids used in heat motors need careful study. Superheated steam is essential to the proper working of a steam turbine, yet many of its properties remain to be investigated. The properties of ammonia and other fluids used in refrigeration are not known accurately, and even the properties of saturated steam are based on Regnault's experiments made nearly seventy years ago. A careful investigation of the properties of heat media of all kinds, extending if necessary over a series of years, would furnish data of the greatest value to engineers, and would in addition be a noteworthy contribution to science.

Considerable work for the railroad interests has already been done by the railway engineering department of the university. This department owns jointly with the Illinois Central Railroad a dynamometer car equipped for steam road experimental work. With this car have been made numerous road tests for the establishment of tonnage ratings. The department also owns a 200 H.P. electric car of the interurban type, especially designed and thoroughly equipped for electric traction work. Railway work with both these cars will be prosecuted vigorously under the direction of the new school of railway engineering and administration recently organized.

It is expected that the Experiment Station will prove helpful to the manufacturing and building interests. In the first place, it will supply accurate data regarding the properties of the materials used in engineering structures and buildings. The laboratory of applied mechanics with its extensive field needs much greater facilities for this line of work, as the reinforced concrete tests now in progress show great possibilities. In the near future, an extensive series of tests on cast-iron columns, and on various forms of steel and iron members is contemplated. Secondly, the Experiment Station will investigate manufacturing processes. As an example of this kind of work the high-speed steel tests are cited. Thirdly, problems relating to design and construction will be studied, and all useful results will be published for the benefit of those engaged in design or construction.

As a rule the Experiment Station will undertake only such investigations as will lead to results of fundamental importance, results that will be helpful to a large class of engineers or manufacturers. It will not, in general, undertake work of importance to individuals only, e. g., the testing of a device or invention for the sole benefit of the inventor.

The Station is now planning to make a more systematic study of the industrial and engineering interests of the state of Illinois, more particularly with the thought in mind that these industries should be advised as to the work already accomplished by the Station, and also that more exact knowledge may be obtained concerning the needs of the various industrial interests throughout the state.

Professor Kenneth G. Smith in the capacity of Industrial Visitor, has during the year, visited the manufacturing centers of Illinois in order to become acquainted with the problems confronting these various interests so that such fundamental problems as affect a large number of our industries can be taken up and such study of these problems made as facilities and funds permit.

There are at present, as already pointed out, fully fifty persons doing some work for the Station; of this number only twenty are devoting all of their time to the station work, the remainder giving but a part of their time to its interests. There are now (May, 1909) in progress nearly sixty different investigations which could doubt-

less be grouped under ten general heads. There are now fully one hundred available investigations waiting for an opportunity to be started and for funds for carrying them forward, as soon as a preliminary survey proves them to be worthy. There will always be, for a station like Illinois, a continually increasing need of such investigations as are planned to be made by the Engineering Experiment Station. The Station is growing to be for the State a *Public Service Research Laboratory* in the realm of industrial science just as it was originally intended it should be, and the results of its experiments will surely add to the wealth of the State, to the prosperity of the industries and to the health and comfort of its people. There will always be fundamental problems of economic importance underlying the advancement of the industrial interests of this State. The Engineering Experiment Station should be ready to assist in the solution of the problems in the field of engineering research. Of fundamental importance are such problems as are indicated by the following list:—

1. The determination of the strength of materials used in constructive engineering work. A very large and important field.
2. A study of the properties and strength of fabricated articles, such as bridges and frame work of important engineering machines and structures.
3. A study of the development, safety and economical use of the machinery and appliances used in mining operations.
4. A study of the problems relating to the economic transportation of passengers and materials by rail (steam and electricity) by water and by air.
5. A study of the economic construction and maintenance of roads.
6. A study of municipal water supply and sewage disposal as affecting public health.
7. A study of the best methods of using economically the fuels of the state, not only for the production of power, but for the heating of buildings, metallurgical purposes, etc.
8. Use of Illinois coal in the gas-producer.
9. Economic production and use of steam.
10. Utilization of oil products for economical and industrial purposes.
11. A study of the development and economic production of manufactured products. A very large field and rich in problems.
12. A study of the generation, transmission and utilization of electrical energy, including economic and satisfactory methods of telegraphy and telephony.

With such a program it is plain that the work of the Engineering Experiment Station can not end so long as the industries of the State are to progress and develop, so long as the fuel problems of the State continue to play such a prominent part in industrial and in domestic use, so long as transportation by steam, by electricity and by water

continues to expand, or so long as a knowledge of the strength of materials continue to play, as it always will, such a vital part in the construction of engineering works, the erection of state and private buildings, and the design and construction of all manner and kinds of manufactured products which our complex civilization now demands.

Perhaps the slow growth of the Station will, in the end, be most satisfactory, but many problems are now waiting for help and much that is new to Illinois interests should be given prompt attention so that every advantage may accrue to its welfare. "A stitch in time saves nine" applies forcefully to scientific research. A knowledge of facts saves much waste.

It is the opinion of the writer,

(1) that the Engineering Experiment Station is now prepared to wisely and economically expend on engineering investigations \$100,000 annually;

(2) that provision for this amount ought soon to be made, and

(3) that when this amount has been wisely spent, provision for future funds will be forthcoming. The greatest single need of the Experiment Station at present is for a new *Materials Testing Laboratory*. A laboratory suitable for this important part of the work of the Station would cost, with its equipment, \$250,000.00. The State should be asked to provide such a building; the work to be done in it would more than repay its cost to the State in four years. The College of Engineering and the Engineering Experiment Station have always received the substantial support and approval of the members of this Society. It has appreciated this support and has endeavored to merit it. It is the hope of the writer that this strong engineering society will feel justified in taking a still greater interest in the engineering work of the State University. Why should not our various organized engineering, manufacturing and mining interests in this State support, back up and push forward the work of the Engineering Experiment Station in just the same way and for the same reason that the various agricultural interests support the interests of the Agricultural Experiment Station? The relation of the engineer and the relation of the Engineering Society to the public are well worth the careful thought of all of us. If the public is to be educated along engineering lines, it is the engineer who must do it. Let the *Western Society of Engineers* do its share in this work and let it do its share without waiting for some other organization to point the way.

Relation of the Station to the Industries.

It has already been shown that the growth and development of the industries of the State of Illinois have been truly marvelous. The work which the Engineering Experiment Station has accomplished, has now in progress or has in contemplation for the future, has been briefly reviewed. It will be seen that some work of the Station

will be helpful to *all* industries, that other work will be helpful to *special* industries and still other work will be of significant value to each and every home.

The continually increasing cost of lumber during recent years has emphasized the necessity of finding some material to take its place. Concrete is rapidly doing this. Everywhere we see this material entering into all sorts of structures. Its use is becoming universal. It is easily transported and handled. The desired mixture of cement, stone and sand can be prepared by machinery and unskilled labor. Combined with suitably located steel bars it is cheaper, stronger and more fire resisting than wood. The cement industry of the country has made the most rapid growth of any of our new American industries. It is extremely important that engineers, architects, and builders should know definitely and accurately concerning the strength and other physical properties of reinforced concrete in all its many and varied forms, mixtures and mechanical treatments. This information the Engineering Experiment Station has been endeavoring to supply, and with, we believe, much success. Eleven bulletins of the thirty-six published have referred to this subject. The first step was the installation of the 600,000-lb. vertical testing machine arranged for testing large and bulky specimens; then came the planning of the work, the making of the tests; then the labor of computations and finally the interpretation of the results and the publication of these results and the conclusions to be drawn from them. The last of these steps is of most vital importance. To do all of these things well is no insignificant task; but they must be done and those engineers who do not know what the results of such tests signify will either use materials wastefully or will design structures that will be temporary and unsafe. Such work as this can not fail to be far reaching and of large economic importance to all the engineering and industrial interests of the State. In the same way the tests of Illinois fuels which have been in progress for four years are of special value and interest to every manufacturer, every railroad company, every power plant both private and municipal and to every home in the State. They are equally valuable to the mining interests of the State. The examination and tests of Illinois coals have been carried forward by several cooperating departments;

- (a) The Technologic Branch of the U. S. Geol. Survey.
- (b) The State Geological Survey.
- (c) The Chemical Department of the College of Science.
- (d) The Graduate School and
- (e) The Engineering Experiment Station and all aided by the special Conference Committee on Fuel Tests,—composed of representatives of the Western Society of Engineers; Western Railway Club; Illinois Manufacturers' Association; Coal Operators' Association; State Electric Light Association; and the Building Managers' Association of Chicago. Seven bulletins of the Station have related

to this important work. The composition, the heating value and the physical nature of Illinois coals have been most carefully studied and set forth as the result of the work carried on under the direction of Professor S. W. Parr, and his work will continue to be of increasing value as time goes on. The experiments by the experts of the Station concerning the burning of Illinois coals under power plant boilers, and in furnaces designed to allow perfect combustion and smokelessness have done much to make Illinois coals worth more in our own and in neighboring states, especially those states north and west of Illinois. A knowledge of the comparative expense of burning briquetted fuel, coke, hard coal, Virginia, Ohio and Illinois coals in different types of residence heating furnaces and boilers can not help but be of value to every home in the State. The bulletin of Dr. J. K. Clement, on the "Rate of Formation of Carbon Monoxide in Gas Producers" is a work of exceptional merit and is a first step in aiding the problem of Illinois coal as a suitable fuel for large gas producers. The coal produced by Illinois has an annual value of \$55,000,000, a still larger amount is doubtless consumed by Illinois industries; the writer would welcome figures on this subject. If the economies pointed out as possible by the Station were carried out, and in many cases they have been, at least 5% of the coal consumed by the State could be saved.

What is true of the Experiment Station's work and tests of concrete and fuel, is equally true of its other lines of work, but thus far more time and money have been devoted to these two lines of work than to others. More need not be said to convince the engineer or the members of this Society, that the work of an Engineering Experiment Station may be as helpful to the progress of industrial Illinois as the work of the Agricultural Experiment Station has been and is to the agricultural interests of the State. It will, perhaps, take more time to educate the general public to understand the possibilities for good which might easily result from a more generous support of such a station. It will be for such societies as this to demand of the Station, such service as it should reasonably be expected to furnish, at the same time urging such generous support by the State for its work, as the results of its past investigations seem to justify or the possibilities of the future seem to promise. There are many investigations which must be made, they are vital to industrial progress. Many of these investigations can be better made by such a station as the one we are now describing than by any other agency. They can be made for less money. They can be made by scientific methods. While they are being made they will help develop the type of man needed by our industries for the more special investigations of the individual or the more highly specialized industry. Several foreign nations have agencies similar to this to make their fundamental industrial investigations. Are not the future interests of the State of Illinois of such importance as to demand the substantial development and extension of

the work now started by its Engineering Experiment Station and should not the engineers and the manufacturers themselves organize to cooperate with the Station in guiding, in protecting and in advancing the researches of the Station in a way that will serve the best interests of this great industrial State?

WHAT WILL AN ENGINEERING EXPERIMENT STATION COST?

The Illinois Engineering Experiment Station has been in active operation for four years. When it was first started it was a matter of some doubt about the wisdom of some of its tests. Funds were available in excess of the pressing needs. This was fortunate because some expensive equipment was necessary to carry out the plans of the future. This equipment was purchased. As soon as the bulletins of the Station began to appear and engineers and manufacturers became acquainted with the work and the objects of the Station, we began to receive requests for tests far beyond the capacity of the Station. At the present time it is absolutely impossible to take up one quarter of the work which comes to us for investigation. It has always been the policy of the Station not to do any work for pay. The reason for this is evident. We refer many inquiries to the proper commercial parties. We are not running a consulting office. The work we do must be of general interest to a large number of citizens. Some work may, nevertheless, be of special interest to certain groups of engineers or manufacturers. Young industries sometimes need preliminary help; it is good State policy to help them.

The expenses of the Experiment Station for the past four years have been as indicated below:—

Expenses of Engineering Experiment Station

1903-4	
1904-5	\$ 25,000
1905-6	25,000
1906-7	30,000
1907-8	33,000
1908-9	37,000
Total	\$150,000

It would have cost three times this amount to have done this work if it had been done independently of the educational work of the College of Engineering. It is clear to the writer that the Station has demonstrated its ability to organize, plan, execute and publish work of great value to the State. It can be trusted with much greater work and it will be better done in the light of past experience and better facilities. The problems in hand and before it for solution involve expense. Some problems must extend over several years in time. Three quarters of all the problems which the Station will investigate will relate to the conservation of the resources of the

Table 4
APPROPRIATIONS TO AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS
AS AUTHORIZED BY FEDERAL LEGISLATION.

ACT	Date	Amount Appropriated for Agricultural Experiment Station Work	Amount Appropriated for Instruction in Agriculture, Mechanic Arts and Allied Subjects	Annual Appropriation in Accordance with the Acts Approved			
First Morrill Act	1862	;) Acres of Public Land for each Senator and Representative		YEAR			
Hatch Act	1887						
Second Morrill Act	1890		\$15,000 for the year 1890 and an annual increase of \$1,000 until the annual appropriation of \$25,000 was reached in 1900.	Annual Appropriation for Agricultural Experiment Station Work			
Adams Act	1906	\$5,000 for the year 1906 and an annual increase of \$2,000 until the annual appropriation of \$15,000 is reached in 1911.		Annual Appropriation for Instruction in Agriculture, Mechanic Arts and Allied Subjects			
Nelson Amendment	1907		\$5,000 for the year 1908 and an annual increase of \$5,000 until the annual appropriation of \$25,000 is reached in 1912.	Total Annual Appropriation			
				Expressed in Dollars			
				1905	15 000	25 000	40 000
				1906	20 000	25 000	45 000
				1907	22 000	25 000	47 000
				1908	24 000	30 000	54 000
				1909	26 000	35 000	61 000
				1910	28 000	40 000	68 000
				1911	30 000	45 000	75 000
				1912	30 000	50 000	80 000
				1913	30 000	50 000	80 000

During the year 1912 and thereafter \$30,000 will be available for Agricultural Experiment Station Work and \$50,000 for Instructional Purposes. No money has been appropriated or is available for Engineering Experiment Station work.

UNIVERSITY OF ILLINOIS, Urbana, Illinois

August, 1909

State and Nation. Where else shall the State go for aid in solving such problems as have been outlined in this paper?

Reference has several times been made to the extensive and valuable work which is being done for the State of Illinois by its Agricultural Experiment Station. This Station receives funds from the Federal Government for aiding its work, but by far the greater part of its funds is appropriated by the State. It is asking the legislature this year, for its use during the next two years, the amounts indicated in Table 3 below:—

Legislative Askings for the Agricultural Experiment Station
1909-1911

1	The College	\$140,000
2	Live stock investigation	140,000
3	Soils	200,000
4	Crops	60,000
5	Horticulture	80,000
6	Dairy	102,300
7	Floriculture	35,000
Total		\$757,300

In addition to this amount for operating expenses, it is asking for buildings, \$162,500.

The funds appropriated to the University by the Federal Government—a part of which are for Agricultural Experiment Station work—are set forth in Table 4. Is it any wonder that the work of the Agricultural Experiment Station should have been important and its researches extensive? No one doubts the wisdom of the expenditures and every one praises the results of its work.

The Engineering Experiment Station is now ready to do great things for the industries of the State. It will cost more money than has yet been appropriated if greater things are to be accomplished.

The writer believes that the industries can afford an extension of the work of its Engineering Experiment Station and that it will pay to make such extension.

DISCUSSION.

President Allen: First let me thank Prof. Breckenridge, on behalf of the Western Society of Engineers, for his most timely and interesting address. Our Society should be in the closest possible touch with the great engineering schools of the West, and such evenings as this are most important in establishing and maintaining such relations.

It is the American idea, and preeminently the western idea, that the education of the people is a function of the State. To this end the State provides its schools, leading from the common school up

to the University, compelling everyone to take the rudiments of education, and offering the very highest facilities for advanced education to those who choose and are able to avail themselves of them. In this way the State itself and the whole people of the State come into a very intimate connection with the State educational system, and with the State University; on the one hand supporting it by general taxation, and on the other hand entrusting to it the education of their youth, and the Western Idea looking to it for instruction, advice and help in building up the industries of the State.

In Illinois—one of the greatest manufacturing and industrial states of the Union—our State University at Urbana is a splendid testimonial to the progress of this idea of mutual aid and cooperation. We all know the crying need of scientific development; how few things in the engineering world are done as well as they might be done, and how few people are trained, and have data at hand, to do things in a scientific and systematic way. The work of the Engineering Experiment Station, as described by Prof Breckenridge, is going to fill a big place in the development of our State. It is certainly a step in the right direction. A great work has been done already, and the possibilities for the future are almost limitless. The work should concern and interest every citizen of the State.

The paper is now open for discussion, and I am glad to see our State University as well represented here this evening. We would like very much to hear from Dr. Goss, Dean of the Illinois College of Engineering.

Dr. W. F. M. Goss, M.W.S.E.: I know, Mr. President, that you, as well as all members present, will agree with me, when I say that we are indebted to Prof. Breckenridge in a two-fold way tonight. We are certainly indebted to him for presenting in such a clear, logical and strong way this story of the problems and work of the Illinois Engineering Experiment Station, which, when published in our Journal, will put before the engineering public a great work and one which is at present somewhat peculiar to the state of Illinois, so far as it is a work which proceeds under state auspices. As yet no other state institution has a regularly organized Engineering Experiment Station proceeding in connection with its engineering college.

The second thing for which we as members of this Society, and as engineers in the state of Illinois, may feel indebted to Prof. Breckenridge, is the larger fact that it has been through his enthusiastic efforts that this Engineering Experiment Station has been established and brought to its present high state of efficiency. I think we may all be proud that we are members of a society in a state where so much has been accomplished for the advancement of scientific information for the benefit of engineers, and that we have with us tonight the man who has laid the foundations, aided in securing financial support, and put the station in a fine state of development.

These are two things for which we should feel especially grateful to the speaker tonight.

On my own behalf and the College of Engineering of the State of Illinois, I want to say that since Prof. Breckenridge is to leave us, and is to sever his connection with this State, there rests upon every one who is interested in the progress of engineering education and the introduction of scientific research, a new responsibility. The work he has carried on so well must be taken up by others, and it will require the reinforcement of interest on the part of everybody in the state who naturally should be interested in that work, in order that it may not fall below the high expectations Prof. Breckenridge has had for it. I take it that while we may have other desires and purposes, yet it will not be a fitting ambition on our part if we do not render all the assistance we can in this matter; we want the work carried on as Prof. Breckenridge wishes it to go on. That I think would be a high idea for the existence of this Station, but of course there are others reasons than that. I am sure the engineers generally feel a great pride in the work which has been already accomplished by the Experiment Station. Most of them know of that work and many have had a part in it, and I do not need to urge the members of this Society to do what can be done to sustain and foster the College of Engineering. Now we are reaching the time when we shall have to call on our friends, when we shall have to urge our friends to think of the needs of the College of Engineering and the Experiment Station, in order that we may go on to new standards and greater prominence. It is true that we have a great college and we are doing our work, but it is also true that our facilities are far below the facilities which ought to be available in this state, for the work which ought to be done. Those of us who stand in the place of Prof. Breckenridge will wish to lean heavily, frequently, on the clientage of the college, its graduates, its friends, and the engineers of the state, for encouragement and support. I cannot refrain from saying, just at this moment, after listening to this excellent address, that a beginning has been made, and the time is coming when, in place of efforts which have been made, we must put forth renewed efforts greater than anything which has yet been done.

Mr. W. L. Abbott, M.W.S.E.: The talk this evening has centered principally around the campus of the University of Illinois, and although there are many here tonight who owe allegiance to other colors and other engineering colleges, I know that each one feels a pride in the work which the engineering colleges of this day, in common with Illinois, are doing in the work of investigations.

One of the principal things which engages the Board of Trustees of Illinois is robbing neighboring institutions of their shining lights,—for instance, President James was secured from Northwestern University, and Dean Goss from Purdue University, and so on down the line. But we have cause to regret that while we

were away on one of our foraging expeditions another institution came along and took one of our best men.

One would think, after contemplating the department that Prof. Breckenridge has built up in the past few years, that he would be content to stay and enjoy the fruits of his labor, but apparently he is possessed of that wanderlust which is characteristic of the Methodist minister, who, after having, by sacrifice and struggle, built a comfortable church in which he could stay the remainder of his life, instead of doing so looks for "new fields to conquer," and moves on again to a churchless parish. So Prof. Breckenridge is going to a benighted institution where he thinks the gospel is needed more than it is in Illinois. He is going to show the people of the East what Western civilization and Western hustle can do. He says that if he is able, he will develop an engineering school at Sheffield, which will compare with that at Illinois, but in case he is not able to do so, he will settle down in academic repose in the land of fried chicken and fresh oysters.

James Lyman, M.W.S.E.: After the remarks of the last speaker, I think it is incumbent upon me, as an alumnus of Yale and a fellow college man with our member Prof. Breckenridge, to call attention to the fact that the great universities and most successful colleges in the West have been started by Yale men. Prof. Breckenridge came West with a splendid groundwork in educational lines and the enthusiasm and spirit of Yale, and it was due partly to that and partly to the fact that he "hailed" from the state of Connecticut (which, although one of the smallest states in area, ranks highest in educational lines), that he has made such a record. The engineering department at Yale is a purely scientific school, and the engineering graduates are all rejoicing in the selection of Prof. Breckenridge to make Sheffield not only a scientific school, but one that shall minister to the needs of the great industrial enterprises of New England and all the East, in establishing such an engineering department as he has created for the state of Illinois. What is loss to the State of Illinois is gain to Connecticut and Yale.

Mr. A. Bement, M.W.S.E. (by letter): As a representative of the Western Society of Engineers on the Conference Committee, organized for the purpose of assisting in the fuel testing work of the Illinois Engineering Experiment Station, I wish to extend my hearty congratulations to Prof. Breckenridge, and to join with the rest of his friends in wishing him the fullest measure of good fortune and success in his new position, and to say that his genial presence will be missed.

The Engineering Experiment Stations are quite a new institution, something with which we have not had much experience, and it has occurred to me that it would probably be appropriate to offer some suggestions having a bearing on their usefulness.

I think it would be desirable to have some form of organization among different stations, so that each may know what character of

research is being conducted by the others, thus avoiding duplication of work. Also that broad and adequate consideration be given to the experimental work which may be undertaken, because it is no easy matter to expend to the best advantage appropriations made for such work. There is danger that the things selected for study may appeal only to the official in charge, and that his viewpoint may govern, rather than that of the requirements of the public.

Aside from the conduct of research, I think the experiment stations have an opportunity to be of great benefit at small expense, by assembling together, properly editing and presenting in bulletins, results secured by other experimenters, which would often be of as great advantage as work that the experiment station might itself conduct.

President Allen: The tide has been running for sometime from the East to the West; now we have the return tide, and Western business men are called to high executive places in the East; Western engineers are in charge of many of the most important engineering works in the East, and now Western educators are going to Eastern Universities. So the West is coming into its own; instead of being a missionary State it is sending its own missionaries abroad.

And now let us wish Prof. Breckenridge a career of splendid success in the East. Our best wishes go with him to his new responsibilities, and he will always find a warm welcome from the State and its citizens to whom he has given so many of the best years of his life.

Prof. Breckenridge: I desire to thank the members of the Western Society of Engineers for all the delightful things they have said to me. I shall always remember the many agreeable things that have come to me during my stay in the West, and when I come to Chicago, it is needless to say I shall always call on the Western Society of Engineers.

I shall also greet with much pleasure members of this society that come to New Haven to visit Yale or to see me, and I shall always be glad to have any of you hunt me up and let me have the pleasure of showing you Yale and particularly the Sheffield Scientific School.

CONCRETE-STEEL CAISSONS: THEIR DEVELOPMENT AND USE FOR BREAKWATERS, PIERS AND REVETMENTS,

By W. V. JUDSON, MAJOR, CORPS OF ENGINEERS, U. S. ARMY.
MEM. AM. SOC. C. E.

Presented May 19, 1909.

For some time work has been progressing in this district (Milwaukee) which has involved the study, design and construction of reinforced concrete caissons for various structures. This system of construction has proved so efficient and economical, and the studies have been so promising that a full account of the work seems desirable.

No dry dock is available in which to construct the caissons, and the development of the latter has been influenced by the fact that the caissons must be built on ways and launched therefrom like any vessel. The heaviest caissons launched have weighed about 119 tons each, but caissons weighing 352 tons each will be built and launched at Milwaukee next summer, and there is no reason to doubt that much heavier caissons can be launched with perfect facility.

The ways that have been employed consist each of three 12 in. by 12 in. stringers, descending into the water with a slope of one on ten. With this slope the caissons start of themselves and do not bind. The stringers are supported on capped pile bents, extend far enough back to give building space, and terminate about six feet under water.

The caisson is begun upon a plank floor, 3 in. or 4 in. thick, which is launched with and forms a part of the caisson. Spikes are driven through the plank so as to project upward into the concrete, and building paper is pressed down upon the plank to reduce the leakage. A temporary wooden deck is used while launching and while towing any considerable distance in the open lake. A caisson is designed so as to have its width and depth proportionate to the work it is to do in a breakwater or pier. Its length is limited partly by the undesirability of too great aggregate weight, but more by the consideration of longitudinal strength, considering the whole caisson as a beam upon which various stresses may be brought to bear under different assumptions as to character of foundations. The reinforced concrete walls, bottom and cross-walls are limited in thickness by considerations of buoyancy, but within the limits of buoyancy it is practicable to design with reasonable economy.

Whether in a given caisson to employ thick walls and few chambers or thin walls and many chambers is a question, in solving which careful judgment should be employed. With thick walls and few of them the cost of putting the reinforced concrete in place is reduced. On the other hand with more numerous walls the spans are reduced

and the caisson even with thinner walls sometimes is a safer structure.

In some cases it would probably be advantageous to substitute interior bracing for some of the cross walls.

In the general case small caissons, say 14 feet square in plan, such as I am using for a number of light-house structures, must be monocellular, for the reason that, if they were divided up, considerations of buoyancy would require the use of such thin walls that excessive care would be required in their construction, and the steel if sufficiently embedded would be too near the center of the walls.

On the other hand, in the case of large caissons, such as the one 60 feet square in plan, hereinafter alluded to, it is best to have numerous chambers, inasmuch as the cross walls, even if there are many of them, may still be of reasonable thickness. It is not believed that in many cases it would be true economy to use caissons which would be lighter in weight than conditions of buoyancy require.

The stresses brought upon a caisson are ordinarily as follows: those due to water pressure upon the outside; those arising from excess of pressure, due to the filling, outward; those due to bending, if the foundation be imperfect and the caisson be supported, for example, under its two ends, or under its middle; and those due to wave action.

When the caisson is launched it may be but ten days old, and the concrete relatively green. When launched, unless long and expensive ways are employed, the caisson plunges low in the water, and the pressure due to the latter is at a maximum.

It is generally found that if the walls and the steel therein be proportioned to care for this initial pressure safely, then the other stresses are negligible, although investigation should always be made as to the sufficiency of the longitudinal strength.

In designing caisson walls and bottoms, several methods have been employed. For a time, following Merriman (*"Mechanics of Materials,"* 10th Edition, 1905), the steel near the surfaces of the walls has been assumed to take up all the tension and compression, the neutral axis to be in the center of the wall, and the concrete to serve only as the web of the beam. Later the more correct and economical theory has been applied, that the steel on the tension side takes up all the tension, while the steel on the other side reinforces the concrete in compression from the neutral axis up. The horizontal steel reinforcement employed in the walls has been distributed in equal amounts on each side of the neutral axis.

Deformed bars are preferred, as plain bars might not form a sufficient bond with the green concrete.

From study and experiment it is believed that the horizontal steel rods in a wall may be proportioned as follows: Assume a reasonable thickness for the wall dependent upon flotation desired, etc., say from 12 to 16 inches. Consider the wall as a series of discontinuous

beams, one above the other, each with a distributed load corresponding to an assumed maximum water pressure. Take the span in the clear without allowance for the filling in of the corners where walls meet (this gives a factor of safety). Neglect the facts that the wall is a slab, due to the presence of vertical rods, and that it is a continuous beam (these give additional factors of safety). Then proportion the steel in accordance with the formulae stated on page 117, *Proceedings of the Am. Soc. C. E. for Feb., 1909*, allowing the steel in tension to be strained to 18,000 pounds per square inch.* Mr. Howard A. Hoeing of this office has prepared from these formulae diagrams by means of which a graphical solution of any ordinary problem of this character can be quickly made.

The diagram shown on Plate I is based on a modulus of elasticity for concrete of 3,000,000, and may be used directly for allowable tensile stresses in steel of 10,000 or 20,000 pounds per square inch. It is easy with a simple computation, to use this diagram for any other selected allowable unit stress in the steel. This diagram is applicable especially to caissons that are built in dry-docks, or in general under such conditions that the concrete may age to 30 days before it is strained.

The diagram shown on Plate II is based on a modulus of elasticity for concrete of 1,250,000, which is reasonably exact for concrete but ten days old, and on an allowable tensile stress in the steel of 18,000.

The use of these diagrams is explained in Appendix I.

In the walls a certain number of rods are introduced vertically. They have generally been placed in pairs, spaced 2 feet apart. The vertical rods add somewhat to the strength of the walls, and reinforce against diagonal tension, considering the caisson as a single beam. They also serve as supports for the horizontal rods in forming.

The steel in the bottom is determined as in the case of a wall. If the caisson is to be placed on a pile foundation, the principal system of rods ordinarily runs longitudinally to support the filling from one pile bent to another. For use on an enrockment the principal rods in the bottom are ordinarily placed transversely. In the bottom, as in the walls, the rods are placed in pairs, one rod near each surface, and again as in the walls, a lighter system of rods is employed at right angles to the main system.

Wherever walls come together, the re-entrant angles are filled in with concrete, as shown on the Plates, and short rods are inserted in these angles to stiffen them.

Inasmuch as no records were available where beams with equal reinforcement top and bottom, and of concrete but ten days old, have been tested to destruction, a few tests of this character have been

*The formulæ are correctly stated in Appendices I and II. There are typographic errors in the "Proceedings" above mentioned.

made. The results of these tests confirm the belief that the method of designing above described will give reasonable factors of safety, which will be increased somewhat by other considerations that have already been mentioned.

The experimental tests indicate that failures due to compression in the concrete need not be apprehended except where the percentage of reinforcement is very large, larger in fact than would ordinarily be employed in caissons following the method of designing proposed. Where the shear is great, however, there should be an investigation as to the sufficiency of the resistance to diagonal tension stresses.

Appendix II, prepared by Mr. J. A. B. Tompkins, Assistant Engineer, describes and analyzes the tests above mentioned and states the formulae recommended by the special committee of the Am. Soc. C. E., which are applicable to the work under consideration. Among the formulae are those for compression in extreme fiber of concrete and for diagonal tension. Considering all of the conditions and the results of the tests, it would appear that at time of launching compressive stresses on extreme concrete fiber up to 1,000 pounds per square inch and diagonal tension stresses up to 50 pounds per square inch, *both as determined by the formulae, where the caisson walls are designed as herein proposed*, would not be excessive.

At the time the caissons are launched, any failure would probably result from failure in the green concrete in portions of a wall where the percentage of steel is greatest, or from tension failures in the steel where the percentage of reinforcement is small. But as the concrete rapidly gains in strength, such designing as I have described would make the walls, after the lapse of time, much stronger, and where the percentage of steel is greatest, approximately equally liable to yield through tension or compression failures. It appears therefore advisable to use steel with a high elastic limit, the gain being most noticeable on portions of a wall where the percentages of steel are relatively small.

A method employed for investigating the longitudinal stiffness of a caisson is shown on Plate III. The 54-ft. Milwaukee caisson has been chosen for purposes of illustration. As this caisson is designed to be supported on four bents of piling, the assumption is made that one of the end bents is cut off too low to perform its function. One-third of the caisson would then be unsupported and would act as a cantilever, bringing the steel near the top of the caisson into tension. Assuming that the concrete serves no function except to unite the steel rods and make them act together, the steel is projected into a beam, under the assumption that all the steel in a given horizontal plane is united together to form part of a flange or web. The maximum bending moment is applied to this hypothetical beam and the tension in the extreme fiber thus determined is assumed to be the tension in the steel rods near the top of caisson.

No difficulty has been experienced in securing water-tight walls. The caissons are constructed of 1:2:4 concrete and the latter is

ordinarily dense enough without treatment. However, the caissons, on the ways, have as a rule been partially filled with water, to test water-tightness, and in some cases a grout wash, containing lye and alum, has been applied to the exterior.

It is believed that the harmful effects of salt water would be reduced to a minimum in the case of the dense concrete of the caissons.

One of the first thoughts that arose, when the permanent filling of the caissons was under consideration, was as to the effect of interior freezing. In the autumn of 1907 a small caisson, 7 feet long, 5.81 feet wide, and 5.67 feet high, with bottom and walls varying in thickness from 4 to 5 inches, was built on the Government dock at Milwaukee, Wis., tumbled off the dock into the water, thus falling 6 feet, towed to the mouth of the harbor, beached in 3.8 feet of water in an exposed location on North Point, filled with sand, and paved over with 6 inches of concrete. This caisson, which is still in place, has not moved perceptibly nor suffered damage from any cause whatever.

The first caissons for actual service were built by days labor at Kewaunee harbor, Wis., during the summer of 1908. They were used in constructing a breakwater at Algoma harbor, Wis.

The caissons, 24 feet long (or 25 feet long with the guide timbers), 15 feet wide and 12 feet 4 inches high, with walls 12 inches thick, one cross-wall 10 inches thick and a bottom 16 inches thick (not including the 4-inch thickness of plank bottom), weighed 11.9 tons each in air. They were constructed on ways, of which three sets were provided, at the rate of one every third day after organization was completed. There were no difficulties encountered in any part of the work. The caissons, temporarily decked, were launched and towed 12 miles in the open lake to Algoma harbor, Wis., where the decks were removed and the caissons parked until they could conveniently be placed in the work. When launched, as the ways terminated but 6 feet below datum, the caissons tilted forward until the decks made an angle of about 30 degrees with the water surface, and sunk until they were just submerged. They immediately righted themselves and floated with a draft of 9.7 feet, corresponding to a freeboard of 2.63 feet.

At Algoma the arm of the breakwater constructed of caissons was 511.7 feet long. The natural depth varied from 15.3 to 13.5 feet. The breakwater faces approximately south-east by south and is exposed to a fetch of about 140 miles measured normally to the breakwater.

At Algoma the caissons were sunk on a pile foundation so as to project one foot above datum when placed. Intermediate between the pile tops and the plank bottoms of the caissons were cast iron disks, covering the pile tops and placed upon them, of course, before the caissons were sunk. These disks were cast with waffle patterns on each side, so that the corrugations, being pressed down into the piles and up into the plank bottom, would introduce a desir-

able amount of friction and at the same time somewhat equalize the loads on the piles. The initial sinking was by means of water, introduced through syphons. The caissons, except several that were filled otherwise for experimental purposes and which will be hereinafter described, were then filled with broken stone to within 4 feet of the tops. The rest of the filling was of lean concrete, and the breakwater was completed by riprapping its sides and adding a concrete superstructure.

I cannot speak too highly of the services of Mr. L. E. Lion, Assistant Engineer, who was in local charge of the work. That this undertaking, when so much was novel, progressed so smoothly was largely due to his skill and careful foresight. Appendix III is a report by Mr. Lion describing all the details of the work. His analyses of cost are especially complete and valuable.

Before the Algoma breakwater was commenced it was estimated that its cost, if built of stone-filled wooden cribs of the type usually employed on this lake, the same being placed on pile foundation and capped with a standard concrete superstructure, would be \$105.18 per lineal foot, and this was the cheapest way, following former practice, in which the breakwater could have been built in permanent form. The estimate for the caisson breakwater was \$103.74 per lineal foot, large unit prices having been purposely assumed because of the novelty of the work. The actual cost of the work proved to be but \$75.67 per lineal foot, although there should be added to this, to make the estimates fairly comparable, \$2.62 per lineal foot to allow for the saving on riprap stone that was obtained from the demolition of the old south pier. It therefore appears that the saving on the Algoma breakwater, due to the use of the caissons, was \$26.89 per lineal foot, or 25.57%.

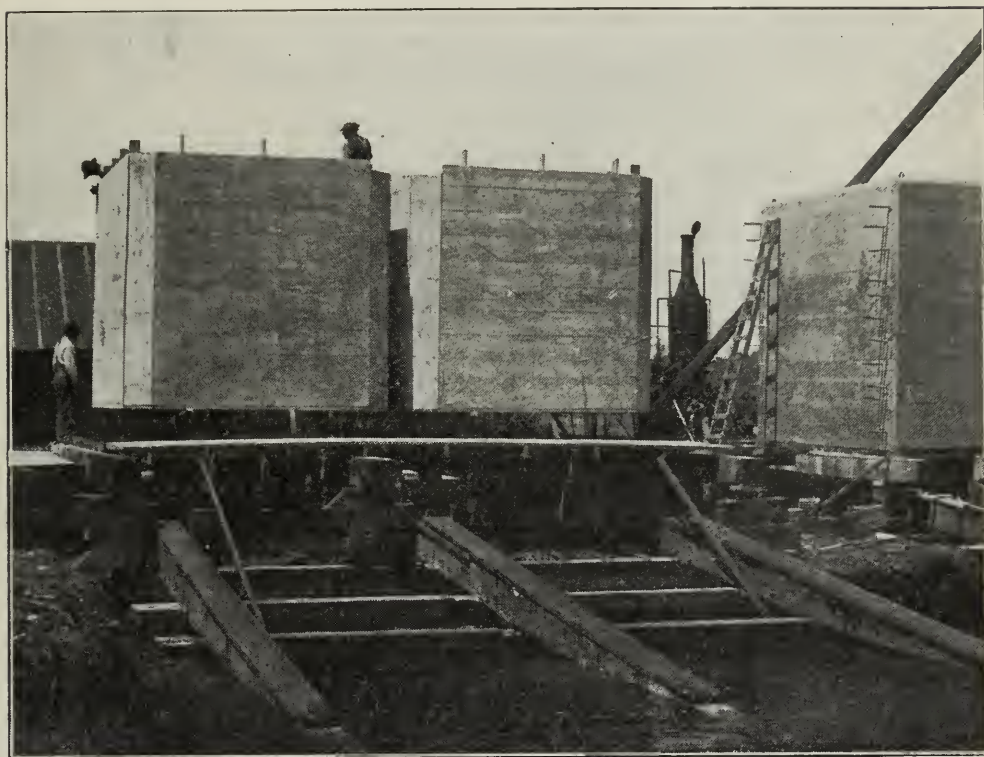
Incidentally it may be said that for the construction of the harbor at Algoma there was available on Jan. 1, 1908, \$44,822 cash, with \$100,000 additional authorized and subsequently appropriated. This was considered but a fair allowance for the work projected, if done by contract, and in fact the prices bid by contractors, after formal advertisement, were so large that the cost would have exceeded the amount available. Using Government plant and days labor, the harbor is now completed, except for dredging 20,000 cubic yards, more or less, and depositing about the pile pier 700 tons, more or less, of riprap, and after this small amount of work is completed in the spring there will remain of the amount originally available at least \$45,000.

Views 1 to 12, inclusive, fully illustrate the Algoma work. Plates IV to VII, inclusive, reproduce in sufficient detail the drawings pertaining thereto.

Referring to Appendix III, the following is a summary of the cost of the caisson breakwater, on a unit price basis:

Cost of the 20 caissons up to delivery at Algoma, Wis.

Item 1.—Cost per cubic yard of reinforced concrete.



VIEW 1.

Reinforced Concrete Caissons for Algoma Breakwater—ready to launch.

Plant charge, including cement warehouse.....	\$0.714
Charge for launching ways.....	0.750
Charge for forms.....	0.908
Materials:	
Cement	\$1.549 per cu. yd.
Sand and stone.....	1.298
Steel reinforcing bars (including wire and spacers)	4.914
Timber in bottoms, decks and guide timbers..	1.275
Nails, spikes and bolts.....	0.522
Fuel and miscellaneous supplies.....	0.225
Labor, including superintendence.....	5.083
Towing 12 miles.....	0.423
Cost per cubic yard.....	\$17.661
Total cost of the 20 caissons, containing 1045 cubic yards of reinforced concrete.....	\$18,456.75

August, 1909

Work at Algoma after caissons were delivered.

Item 2:—Cost of 820 cubic yards 1:5:10 concrete filling.

Materials and labor:

Cement 0.735 bbls. per cu. yd., at \$1.15.....	\$0.845
Aggregate, 1.001 cu. yds., at \$1.25.....	1.251
Handling cement, per cu. yd. of concrete.....	0.033
Handling aggregate, per cu. yd. of concrete.....	0.314
Labor and superintendence, per cu. yd. of concrete...	1.295
Fuel, per cu. yd. of concrete.....	0.189
	<u>\$3.927</u>

Plant charge, including warehouse..... 0.890

Forms 0.030

Total per cubic yard.....\$4.847

Total for 820 cubic yards.....\$3,974.54

Item 3:—Cost of 421 cubic yards 1:3:5 concrete superstructure.

Materials and labor:

Cement, 1.264 bbls. per cu. yd. of concrete, at \$1.15.....	\$1.454
Aggregate, 0.998 cu. yd. per cu. yd. of concrete, at \$1.25..	1.248
Handling cement, per cu. yd. of concrete.....	0.059
Handling aggregate, per cu. yd. of concrete.....	0.359
Labor and superintendence, per cu. yd. of concrete.....	2.660
Fuel, per cu. yd. of concrete.....	0.189
	<u>5.969</u>

Plant charge, including warehouse..... 0.890

Forms 0.525

Total per cubic yard.....\$7.384

Total for 421 cubic yards.....\$3,108.66

Item 4:—Pile foundation, 376 piles, aggregating 15,040 lin. ft.

Cost of piles.....\$2,481.60

Cast iron pile disks..... 176.40

Labor and superintendence; sharpening, driving, cutting
off and leveling pile foundation..... 1,261.34\$3,919.34

Plant charge 320.00

Total\$4,239.34

Cost per pile $4239.34 \div 376 = \$11.275$.

Item 5:—Riprap stone.

Large stone purchased, 1572.45 tons, at \$1.19.....	\$1,871.22
Small stone purchased, 3825.52 tons, at \$0.98.....	3,749.01
Riprap from demolition, 1231 tons, at \$0.25.....	307.75
Labor and superintendence placing purchased riprap...	1,718.24
Time of dredge casting riprap.....	124.41
Plant charge, scows and derrick.....	264.00
	<u>\$8,034.63</u>

Total cost of 6628.97 tons of riprap in place.....\$8,034.63

Cost per ton $8034.63 \div 6628.97 = \$1.212$.

Item 6:—Miscellaneous.

Setting ranges and preliminary work.....	\$ 71.81
Removing decks and preparing caissons for sinking.....	329.07
Towing with gasoline launch.....	323.25
Miscellaneous supplies	181.65

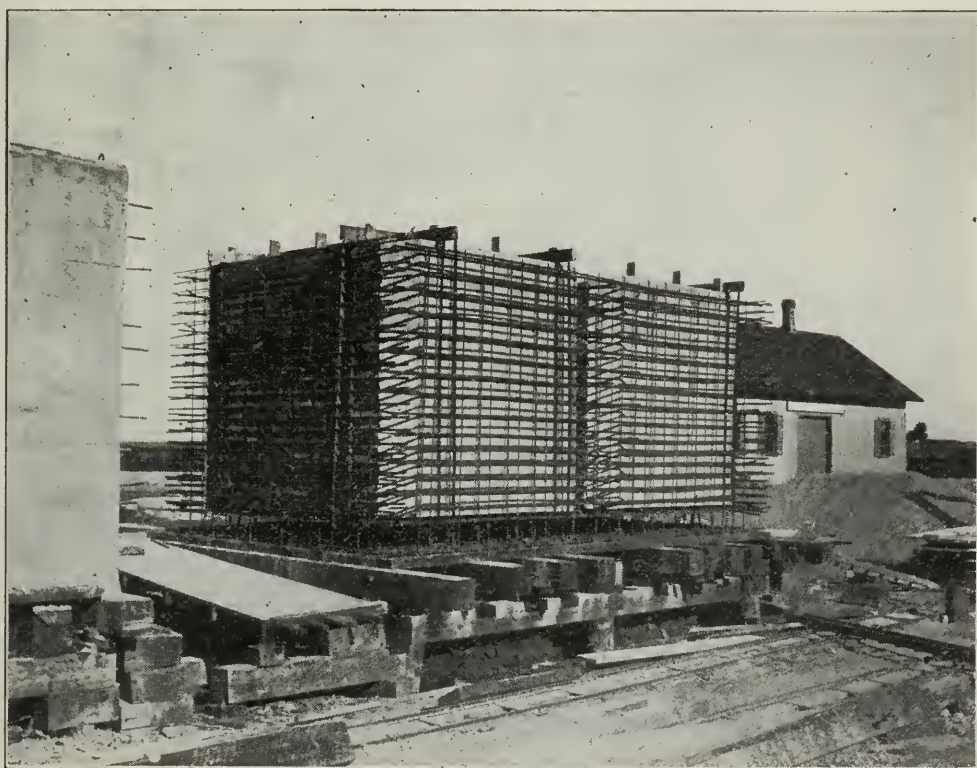
\$905.78

Total cost of 511.7 lineal feet of breakwater; aggregate of

Items 1 to 6 inclusive.....\$37,718.58

Cost per lineal foot of completed breakwater.....\$75.67

Having thus stated in detail the cost of the Algoma work it is



VIEW 2.

Reinforced Concrete Caissons under construction.

proper to study the figures with a view to ascertaining how estimates for future work of a similar character may be based upon them.

First, it is to be remembered that the working hours were eight per day, except that during the favorable working months of July, August and September, by Executive Order, the hours on Saturdays were reduced to four, although payments were made for full time.

Second, the harbor at which the caissons were built was 12 miles distant from the harbor where they were used. Under more favorable conditions in this respect the towing charge would be much reduced. Moreover, as the caissons were to be towed from one harbor

August, 1909

to another in the open lake the temporary decks employed were more numerous, and the expense of placing the decks (calking, etc.) was greater than would have been the case if a deck had been needed when launching only. In the case of larger caissons the timber bottoms, per cubic yard of concrete, would also be much reduced, and it is proposed hereafter to omit the guide timbers at the ends of the caissons.

Third, the total volume of the Algoma work was small, but 511.7 lineal feet of breakwater, containing 1,045 cubic yards of reinforced concrete, having been constructed, although 22 caissons, containing 900.62 cubic yards, were built for Manitowoc harbor during the same season and with the same ways and plant, thus reducing the charges for these items. The Algoma caissons, and the Manitowoc caissons as well, were small compared with others projected. The walls and bottoms were relatively thin, and for a given expenditure they did not run rapidly into "yardage." It is probable that larger caissons, employed to build more considerable lengths of breakwater, would cost considerably less per cubic yard for plant, forms, ways and labor.

Fourth, in the case of the Algoma caissons 248 pounds of steel per cubic yard of concrete was employed. Careful study has shown that in the case of the larger caissons with cross-walls suitably spaced the steel can be safely reduced by a considerable amount.

All of these considerations lead one to believe that, where the amount of work is sufficiently large, the cost of the reinforced concrete of the caissons in place in the finished work may be estimated under conditions now obtaining in this vicinity at about \$16 per cubic yard, inclusive of all materials, labor, plant and contractor's profit. But it is doubtful whether contractors will take their first work of this character, on account of its novelty, at figures quite so low.

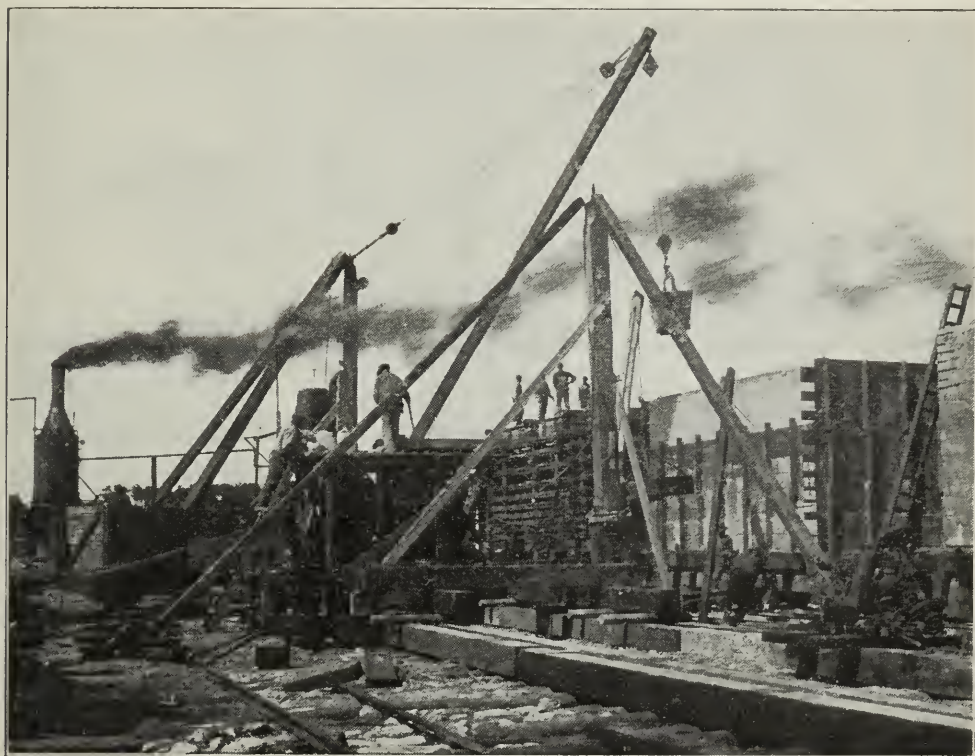
Five of the Algoma caissons were filled in experimental ways for the sake of securing information. The 16th and 17th caissons from the northerly end were filled with sand to within four feet of the top, and the upper four feet with 1:5:10 concrete which was supported by posts extending through the sand to the bottoms of the caissons. The 18th caisson was filled with sand to within two feet of the top, and the upper two feet with 1:3:5 concrete. No supporting posts were used in this caisson. In the 19th caisson sand was used for filling to within two feet of the top, the upper two feet being filled with 1:3:5 concrete, which was supported by posts. The 20th caisson was filled with riprap stone to within one foot of the top, and the upper foot filled with 1:3:5 concrete supported by posts.

The first caisson for Algoma was molded on June 1, 1908, and the last on August 24, 1908.

With the same plant, at Kewaunee harbor, the construction was immediately begun of a number of caissons required for use at Mani-

towoc harbor, Wis., 29 miles distant. By this time the force was so well organized that it was found desirable to build one caisson every other day. To secure working space, caissons four days old were moved part way down the ways without difficulty. The Manitowoc caissons are 24 feet long, 14 feet wide and 11 feet 4 inches high. The bottoms are 18 inches thick (including 4 inches of timber). The walls are 10 inches thick and the cross-wall 8 inches thick. 22 caissons were built for Manitowoc, of which one was of "special" shape. Eleven of these caissons were towed to Manitowoc and parked for the winter in the river; the rest were stored at Kewaunee.

Two special caissons still remain to be built for the Manitowoc work, which will include about 580 lineal feet of concrete caisson



VIEW 3.

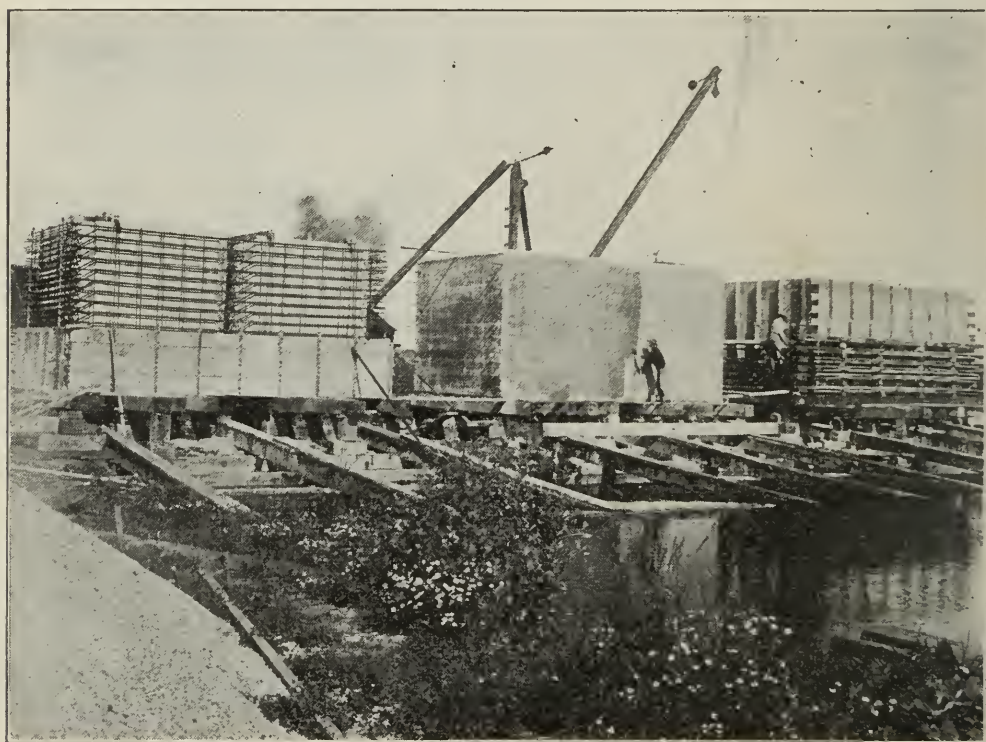
Reinforced Concrete Caissons under construction—rear view.

breakwater, completing the projected harbor there. Next spring the Manitowoc caissons will be sunk on a riprap foundation and filled with lean concrete. Eventually they will receive a concrete superstructure, but not before they have stopped settling. The Manitowoc caissons are illustrated on Plates VIII and IX.

A contract has recently been let for the reconstruction of the south pier at Milwaukee harbor. The outer 216 lineal feet of this work will consist of four caissons, each 54 feet long and 18 feet wide. The bottoms will be 21 inches thick, including 3 inches of planking. The side and end walls will be 14 inches and the two cross-walls each 12 inches thick. These caissons will weigh 352 tons each. The

next 360 feet of pier will consist of 10 caissons, each 36 feet long and 15 feet wide. The bottoms will be 19 inches thick, including 3 inches of planking. The side and end walls will be 12 inches and the two cross-walls each 10 inches thick. These caissons will weigh 175 tons each.

The Milwaukee caissons will be built on and launched from ways located at Milwaukee belonging to the United States. They will be sunk on pile foundation, as dredging must be done close up to them. The United States will furnish the piles and the reinforcing rods. The contract prices are \$7.50 each for driving and cutting off the piles; \$15.50 per cubic yard for reinforced concrete in place; \$1.45 per ton for filling stone and riprap; and \$6.00 per cubic yard for lean concrete filling.



VIEW 4.

Reinforced Concrete Caissons under construction, and ready to be launched.

The designs of the Milwaukee caissons are shown on Plates X to XII, inclusive.

The caissons thus far described have had vertical walls of uniform thickness from top to bottom, except that the walls of the Milwaukee caissons are to be thickened somewhat at the top, the better to hold the steel needed for longitudinal stiffness, and to avoid weakening the caissons at the top where timber is ordinarily let into the concrete for the purpose of holding the decks.

It is obvious that caissons with walls inclined inward from bottom to top would better resist wave action. Per cubic yard of contents

they would possess greater moments of stability against overturning and at the same time the overturning moment due to wave action would be lessened, inasmuch as the wave pressure would act normally to the inclined front surface, and thus have a reduced lever arm.

It is also obvious that, as the walls are ordinarily subjected to the greatest pressure at points near the bottom, they may to advantage be made thicker near their bases.

To meet typical conditions in breakwater construction and the like a number of caissons have been designed and it is now proposed briefly to describe them.

Plates XIII and XIV, show a breakwater designed for an exposed location in Lake Michigan, where the water is 34 feet deep. With stone at \$1.40 per ton, timber at \$40 per M. ft. B. M., reinforced concrete at \$16.00 per cubic yard, lean concrete at \$5.00 per cubic yard, and superstructure at \$9.00 per cubic yard, the cost per lineal foot of this breakwater would be \$203.10 as against a cost of \$206.20 per lineal foot for a breakwater of the ordinary type, wooden cribs, 30 feet wide, stone filled, on riprap foundation, with timber superstructure, taking timber at \$40.00, iron at 5 cents per pound and stone at \$1.40 per ton, all unit prices covering materials in completed work.

To carry the comparison further, it may be said that in from 12 to 15 years the wooden cribs would require a new superstructure, which if built of concrete, in accordance with the usual practice, would cost from \$70 to \$100 per lineal foot.

The efficiency of the caissons to resist overturning by wave action would be about 1.2, if 1 be taken to represent the corresponding efficiency of the wooden cribs.

Plates XV and XVI, represent a caisson designed as the top of an enrockment breakwater in an exposed location in 42 feet of water.

The cost of such a breakwater, at unit prices similar to those above mentioned, would be \$273.42 per lineal foot, as compared with a cost per lineal foot of \$261.75 for a 30-ft. wide wooden crib breakwater. But again the top of the wooden crib would be temporary, and the efficiency of the concrete caissons to resist overturning would be 1.7 times the efficiency of the wooden cribs. In this connection the recent partial failure of the 30-ft. wooden crib breakwater at Michigan City, Ind., is deserving of consideration. The depth of water at the outer end was about 30 feet, and the breakwater was exposed to waves with a fetch corresponding to the greatest dimension of Lake Michigan. It is understood that the outermost crib was overturned toward the harbor side in a recent storm.

Plates XVII and XVIII, represent a caisson designed to surmount an enrockment and form a breakwater in an exposed location in 48 feet depth of water. The breakwater complete would cost \$335.03 per lineal foot, and its efficiency to resist overturning would be nearly twice that of a stone filled 30-ft. wooden crib breakwater.

The three sloping wall caissons last described have been carefully studied. If the enrockment were so uneven as to support a caisson

under its middle, or under its two ends only, no harm would result. Specifications have been worked out for building a breakwater of either of these caissons, on stone foundation, but space is lacking to discuss at this time the proposed details of the work.

Plate XIX illustrates a caisson designed to surmount an enrockment and form a breakwater in an exposed location in salt water and on a soft foundation. Concrete is employed as a filling with a view not only to its weight, but in order to reinforce the parts of the caisson that are to be most exposed to the action of sea water. With reinforced concrete at \$17 per cubic yard, filling concrete at \$6, superstructure concrete at \$9, enrockment at \$1.40 per ton, and reinforced concrete slabs and columns at \$11 per cubic yard, this breakwater, in 50 feet depth of water, would cost \$611.22 per lineal foot. Voids are left in the interior of the caisson to reduce the weight on the foundation. Assuming that, due to arching effect in the enrockment, the weight is so spread upon the bottom as to be uniform for a width of 44 feet on each side of a vertical plane bisecting the caisson longitudinally with the breakwater, then the weight on the bottom will be 3,034 pounds per square foot. The berms in the case of this enrockment are protected on the sea side by reinforced concrete slabs each weighing 15 tons.

Figures 1 and 2, Plate XX, illustrate a possible use of caissons, one on top of a second, for the construction of a breakwater in deep water on a soft bottom where it is necessary to reduce the weight to a minimum. The lower caisson, at unit prices last mentioned, would cost \$345.78 per lineal foot of breakwater, and the upper caisson with filling and superstructure would cost \$250.98 per lineal foot, making the total cost of the breakwater \$596.76 per lineal foot. The weight per square foot brought upon the bottom by such a combination of caissons as is last described would be 1866 pounds.

Another suggestion for a breakwater in salt water, where piles are required by reason of the poor foundation available, and where, unless they were protected, the pile heads might be destroyed by the teredo, is shown in Fig. 3, Plate XX. This caisson would be provided with large pipes, or wells, through which, after the caisson is sunk in place, concrete would be forced down among the pile tops. The space into which the concrete would be forced could be shut in on the sides by dumping dredged material close beside the caisson.

In some localities small stone is cheap but large blocks of stone are not to be had. In such cases small caissons may be used to cover the top of an enrockment, the side slopes being protected by reinforced concrete slabs. Such a breakwater is illustrated on Plate XXI. It would cost, if the caissons were filled with lean concrete, about \$70. per lineal foot, at prices now prevailing on Lake Michigan. Even where large stone is available for the top course of an enrockment, the difficulties are well known of laying the large stone so that subsequent settlement and wave action will not cause serious disarrangement. The solid concrete top afforded by the caisson method

and the protection of the slopes with reinforced concrete slabs would promise greater permanency than any simple enrockment. After settlement a suitable superstructure could be provided, although in the general case one would probably be unnecessary.

Plates XXII and XXIII illustrate studies for breakwater caissons in which extra freeboard has been provided as a precaution against settlement, and at the same time to insure easy construction of the superstructure by making the upper part of the caisson a part thereof. The use of such caissons would diminish risks that may be encountered after the caissons are in place but before they are filled, and would diminish the cost of the superstructure. These advantages would sometimes be offset by the greater cost of the caissons.

The use of caissons somewhat similar to those heretofore described readily suggests itself for the construction of dock fronts or revetments, without the expense of coffer-damming.

A design for such a dock front is shown on Plate XXIV. It will be observed that the front and back walls of the caisson forming this revetment slope backward from the bottom up. If this shape be given to the caissons it is still practicable, with or without ballast, to insure that in floating the top and bottom shall be substantially in horizontal planes. The result of inclining the walls backward is to remove the center of gravity to the rear, thus removing the center of pressure back from the toe of the revetment and adding to stability. At the same time, as the rear surface of the revetment is inclined from the vertical and approaches the angle of repose of the material to be retained, the pressure on the revetment is decreased.

It is believed that, under most conditions that obtain, permanent dock fronts or revetments of a given efficiency can be built more cheaply as above described than in any other manner.

For purposes of comparison, it may be said that the Sanitary District of Chicago recently constructed in Chicago river 782 lineal feet of concrete dock front at \$144.26 per lineal foot, not including dredging nor back-fill. The revetment was supported on piles, and a coffer-dam was of course required for its construction. Employing slightly inclined caissons, like that shown on Plate XXIV, thus obviating the use of coffer-dams and economizing on concrete, an equally stable, durable and sightly dock front could be constructed for less than \$90.00 per lineal foot.

Reinforced concrete caissons are especially adapted for use as light house foundations. Plate XXV, illustrates a caisson 60-ft. by 60-ft. in plan and 24 feet high, which might be constructed in a "mud" dock at any convenient place, temporarily decked, towed into position, sunk and filled with lean concrete. It could readily be used on any suitable natural bottom or prepared foundation. Its stiffness would be such as to make it safe regardless of inequalities beneath. If it were capped with a solid block of concrete of great weight the latter should be reinforced top and bottom, both ways, so as to constitute a thick slab, thus preventing it from imposing any unnecessary function upon the filled caisson below.

A fair estimate of cost of such a caisson, with its filling, but not including superstructure nor foundation, is as follows:

Reinforced concrete, 887 cubic yards, at \$25.....	\$22,175.00
Timber, 19,332 ft. B. M., at \$50. per M.....	966.60
Filling, 2,280 cubic yards lean concrete at \$5.....	11,400.00

Total cost	\$34,541.60
------------------	-------------

The high unit price of reinforced concrete was taken so as to include in the cost of the concrete the mud dock and the towing to destination. It is suggested that the lean concrete might be mixed dry, stored in the hold of a vessel and taken out to the site therein, deposited in the pockets of the caisson with a clam-shell bucket, and furnished with water through suitable holes opened at the proper time in the caisson walls.

The estimated cost of this caisson, \$34,541.60, may be compared, making proper allowances, with the actual cost of the wooden stone-filled crib, capped with concrete blocks, which forms the base of the White Shoal light-house, now under construction in Lake Michigan. The latter structure is 72 feet square in plan, 22 feet 6 inches high and cost approximately \$40,199.27.

Plate XXVI, illustrates a small pier which will soon be constructed at Bank Point, Muskegon harbor, Mich. The caisson, 14 feet square in plan, will be placed on piles, filled and capped with concrete and surmounted by a concrete-steel post bearing an acetylene lamp. The latter will be supplied with gas from tanks for which recesses will be left in top of the pier.

In several of the plates last mentioned, no attempt has been made to show the distribution of the steel. It could easily be proportioned in accordance with the methods herein described.

The use of reinforced concrete caissons for breakwaters, bulkheads and the like appears to be undergoing development simultaneously in Europe and in America. Press reports state that at Kobe, in Japan, caissons are to be built 120 feet long, 26 feet wide and varying from 32 to 41 feet high, to form the quay walls of a new harbor. It is proposed to build these caissons on timber stagings, from which they will be lifted by a special depositing dock, taken into deep water, allowed to float off the dock by sinking the latter, and then towed to their destination.

Similar but smaller caissons are being employed at the port of Barcelona. These caissons are put afloat, it is understood, by means of a depositing dock similar to that mentioned above. In some cases, probably in most cases in which caissons have recently been used abroad, they have been built in dry docks.

In recent technical publications there have been brief accounts of the employment of reinforced concrete caissons for docks at Amsterdam, and for a breakwater at Touapsé. The published Proceedings of the International Congress of Navigation, held at St. Petersburg, 1908, contain most of the information that is now available in America on this subject.

Briefly speaking, the many advantages afforded by the use of reinforced concrete caissons include economy, both initial and ultimate, durability and sightliness.

The great stiffness and substantial character of the caissons render it practicable to tow them long distances independent of conditions of the sea. Many risks, incident to the use of other caissons or wooden cribs, are eliminated.

When over their foundation, if desired, the caissons may be quickly filled with water by using a sufficient number of syphons, or by means of valves, and with this contained water the caisson becomes at once safe against moderate seas. When sunk, the tops of the caissons project above the water surface and the walls form coffer-dams so that the chambers may be successively unwatered and the filling put in dry if desired.

When a timber crib is capped with a concrete superstructure, it is necessary to employ blocks to build up from a plane say 2 feet below the water surface to a plane say 2 feet above the latter. It is difficult to provide a bond between the blocks and the timber, so that the monolithic concrete placed on the blocks must be massive, with a view to holding down the blocks by weight alone. In the caissons, the upper parts thereof correspond to the blocks, and are of course solidly bound to the structure beneath. Hence a much less massive superstructure is required.

During construction the plant may be centralized. After a caisson is built, gravity carries it down the ways and makes clear the working place. The construction of a piece of work employing a considerable number of similar caissons lends itself to organization and consequent economies that ordinarily result only from the favorable conditions under which factory work is prosecuted.

The cost of timber is rapidly appreciating, and the time when temporary structures were good enough is passing. There is probably much to be learned about reinforced concrete caissons, and much educational work to be done among contractors, but apparently in no field will reinforced concrete make greater strides in the immediate future than in such works as breakwaters, piers, dock-fronts, revetments, bridge piers and similar structures where reinforced concrete caissons may be employed.

APPENDIX I.

DIAGRAMS FOR REINFORCED CONCRETE BEAMS HAVING EQUAL REINFORCEMENT TOP AND BOTTOM.

BY HOWARD A. HOEING, U. S. Inspector.

The curves given are based on beams having the reinforcing steel in both top and bottom of beams; top steel and concrete in compression; bottom steel in tension; no tension in concrete; steel on both sides having same cross-section area and imbedded 2 inches from center of gravity of steel to surface of concrete.

The curves are plotted from the following formulae taken from "Proceedings of the American Society of Civil Engineers," Feb., 1909:

$$k = \sqrt{2n \left(p \times p' \frac{d'}{d} \right) \times n^2 (p + p')^2 - n (p + p')}.$$

$$z = \frac{\frac{1}{2} k^3 d + 2 p' n d' \left(k - \frac{d'}{d} \right)}{k^2 + 2 p' n \left(k - \frac{d'}{d} \right)}.$$

$$j d = d - z.$$

$$f_s = \frac{M}{p j b d^2}$$

in which k =ratio of depth of neutral axis to effective depth, d .

E_s Modulus of elasticity of steel

$$n = \frac{E_s}{E_c} = \frac{\text{Modulus of elasticity of steel}}{\text{Modulus of elasticity of concrete.}}$$

p =steel ratio for tension steel

p' =steel ratio for compression steel

d =depth to center of tension steel

d' =depth to center of compression steel

b =breadth of beam

z =depth of resultant compression below top

j =ratio of lever arm of resisting couple to depth d

f_s =unit tensile stress in steel

M =moment of resistance

In the above the values of n , f_s and b are constant, $p=p'$

To obtain the curves, successive values of p were assumed and the corresponding values of M in inch-pounds per inch width of beam were derived from the above formulae, the values of p being plotted for abscissas and the values of M for ordinates.

As a special application for the design of caissons the bending moments for beams of different loads and spans figured from heads of water are also plotted. The abscissas reading from right to left representing heads of water in feet; the ordinates, the bending moments on the same scale as the resisting moments of the beam diagram.

Plate I is based on unit tensile stresses in the steel of 10,000 and 20,000 pounds, the resisting moments corresponding to 10,000 lbs. tensile stress being the ordinates at left of the diagram, those corresponding to 20,000 lbs. tensile stress, those at right. Modulus

of elasticity of concrete taken at 3,000,000. Modulus of elasticity of steel taken at 30,000,000. For 10,000 lbs. stress in steel use upper row of depth of water, for 20,000 lbs. use lower row.

Plate II is based on a unit tensile stress in the steel of 18,000 lbs. and a modulus of elasticity of concrete of 1,250,000, the values of p and M being plotted same as in Plate I.

To apply the diagrams find the ordinate representing the head of water required, then find the intersection of this ordinate with the line representing the required span of beam, which gives the bending moment or resisting moment of the beam, read on the vertical scale at the left or right. Follow the horizontal line just found to the right or left until it intersects the curve of the beam having the depth desired and read value of p on horizontal scale. Or the bending moment may be computed for any load and value of p found direct.

The value of p having been found, assume the area of the reinforcing bar desired, then
$$\frac{\text{assumed area of bar}}{p} = \text{area of concrete}$$
 above steel in tension.
$$\frac{\text{Area of concrete}}{\text{Depth of beam in inches} - 2} = \text{spacing of steel in inches.}$$

Example: Given a beam 16 in. in depth, span 20 ft. load on beam equal to hydrostatic pressure of 8 ft., unit tensile stress in steel = 10,000 lb. From Plate I, for 8 ft. depth and 20 ft. span, $M = 25,000$ inch-pounds, value of p corresponding to 25,000 inch-pounds on 16 in. beam is 0.0146.

Assume area of bar = 1.56 square inches, then
$$\frac{1.56}{0.0146} = 106.84.$$

$$\frac{106.84}{16 - 2} = 7.63 \text{ inches c. to c. spacing of steel.}$$

To apply a diagram using a unit stress in steel other than that for which diagram is plotted, multiply the bending moment by ratio between unit stress of diagram and assumed unit stress; the product will be the resisting moment of the beam under assumed unit stress in steel. Then proceed as before.

APPENDIX II.

DESCRIPTION OF TESTS OF REINFORCED CONCRETE BEAMS.

BY MR. J. A. B. TOMPKINS, U. S. ASST. ENGINEER.

MEM. AM. SOC. C. E.

The beams tested were representative of sections from the side walls of reinforced concrete caissons designed in this office.

August, 1909

As it is proposed to launch caissons ten days after molding and as caisson walls are then subjected to their maximum loads, all beams were tested at the age of ten days.

The concrete for all beams consisted of one part cement, two parts stone-crusher sand or stone dust, and four parts broken stone, proportioned by volume without compacting, one bag of cement being taken as equivalent to one cubic foot. The concrete was a wet mixture of about the same consistency as the concrete used in moulding caissons.

Two brands of cement were used, beams being designated A or U in the accompanying table, according to the cement employed in their manufacture. The cement was purchased in the open market. Briquettes made from the cement developed tensile strength at the age of seven days, as follows:

Neat A cement.....	833 lbs. per sq. in.
Neat U cement.....	709 lbs. per sq. in.
1 part A cement, 3 parts sand.....	204 lbs. per sq. in.
1 part U cement, 3 parts sand.....	168 lbs. per sq. in.
1 part A cement, 2 parts stone dust.....	429 lbs. per sq. in.
1 part U cement, 2 parts stone dust.....	379 lbs. per sq. in.

The stone dust and broken stone were of crushed limestone, of the size used in building caissons at Kewaunee, Wis., and of the same character, except as to size, that has generally been employed. The stone dust consisted of the finer particles of such size that all would pass through a $\frac{1}{4}$ -in screen. The broken stone was of such size that all would pass through a $\frac{3}{4}$ -inch screen and be retained upon a $\frac{1}{4}$ -inch screen.

Each beam was reinforced top and bottom by four steel bars of equal cross-section, symmetrically arranged and at a distance of two inches from surface of beam to center of bar. Both deformed and plain bars were used for reinforcement. The plain bars were of ordinary medium steel, purchased in the open market. Two styles of deformed bars were used, designated J and R in the accompanying table. The J bars were corrugated; the R bars were twisted. All deformed bars were intended to have been of high carbon steel, but owing to some oversight the bars in beams 3A and 3U were of soft steel of inferior quality. Two other beams of the same size, designated 4A and 4U were then molded in which high carbon steel was used. All bars were laid straight, without turning up the ends. The bars in all cases were of the same length as the beams, so that the ends of the bars were visible in the ends of the beams.

The beams were molded in a building where a fire was maintained day and night, and were kept in the building until tested. Beams 1A and 1U gave rather low results in diagonal tension, and the concrete was found to be of poor quality. As the concrete for these beams was mixed with water but little above the freezing point, two additional beams, designated 2A and 2U in table, of the same size and

TABLE.—TESTS OF BEAMS REINFORCED AGAINST TENSION AND COMPRESSION.

Dimensions			Reinforcement	Applied Load	Load Considered	Bending moment	Equivalent Uniform Load	Strength Per Square Inch		Calculated Stresses per sq. in. (lb.)					REMARKS	
Depth	Width	Span						Concrete (Compression)	Steel Tension		f _c	f _s	f _s ^t	t		u
									Yield	Ult.						
In.	In.	Ft In.		Lbs.	Lbs.	In.-Lbs.	Lbs.									
12	13	10-9	J. bars, 0.76-in. ² area spaced 6½" ctrs.	25824	27510	490856	30378	900	.....	.....	1230	38700	15900	96	235	Failed in diagonal tension. Observed point of failure 16½" from abutment *
12	13	10-9	do do do	28024	29710	529122	32814	1150	.....	.....	1330	41800	17200	135	255	Failed in diagonal tension.
12	13	10-9	do do do	22614	24300	432431	26817	600	.....	.....	1050	34100	14000	85	210	Failed in diagonal tension. Observed point of failure 18" from abutment.†
12	13	10-9	do do do	20856	28542	508216	31517	800	.....	.....	1280	40100	16500	130	245	Failed in diagonal tension.
14	11	14-9	J. bars, 1.00 in. ² area spaced 5½" ctrs.	25000	27300	665481	30078	1000	30000	41500	1110	32900	16600	125	170	Failed in tension—an increment of 1000 lbs. † caused so great deflection that load rested on ground.
14	11	14-9	do do do	27400	29700	724482	32745	1250	33000	46000	1200	35800	18100	135	185	Failed suddenly in tension—beam deflected so greatly that load rested on ground.
14	11	14-9	do do do	31200	33500	817888	36972	1350	51700	80300	1360	40400	20400	150	205	Diagonal tension failure.
14	11	14-9	do do do	22880	25180	613364	27723	1250	51700	80300	1020	30300	15300	115	155	Diagonal tension failure.
12	10½	10-9	R. bars, 0.39-in. ² area spaced 8¼" ctrs.	31360	33520	506684	37003	1350	62600	79000	1910	88200	19100	105	385	Failed in tension by steel breaking.
12	10½	10-9	do do do	23840	29600	461953	28648	800	63100	82100	1480	68300	14700	90	300	Cause of failure somewhat doubtful—probably failure of bond. Steel slipped from end.
12	16½	10-9	Plain bars, 0.39-in. ² area spaced 8¼" ctrs.	23440	25600	454787	28204	1550	43500	60100	1460	67200	14560	90	295	Failed in tension by yield of steel.
12	16½	10-9	do do do	15080	17240	305007	18915	900	44500	60600	980	45100	9700	60	200	Failed in bond.

Minimum diagonal tension at abutment 125 lbs. per sq. in.

Minimum diagonal tension at abutment 110 lbs. per sq. in.

NOTE: In the column headed "t" the diagonal tensions stated are derived in all cases from the maximum shear at the abutment, except for beams I-A and I-U, where the diagonal tension given is that observed at the observed section of failure.

with the same reinforcement as 1A and 1U were molded, using water at a temperature of 130 deg. Fahr.

When ready for testing, a beam was placed on timber abutments and loaded to destruction by piling pig iron on four platforms suspended from the beam. The platforms were hung from eight 4 in. by 6 in. timbers spaced equidistant along the top of the beam, by $\frac{5}{8}$ -in. round rods, spaced two feet apart transversely to the beam, there being two timbers and four hangers to each platform. By this method the beam was loaded approximately equally at eight points. Considering applied loads only, the resulting bending moment is therefore $1\frac{1}{9}$ times the moment of the same load uniformly distributed.

The loads were applied in increments of about 1,000 lbs., care being taken that successive increments were reasonably uniformly distributed over the platforms, both longitudinally and transversely to the beam. Deflections at the middle of the span under successive load increments were observed. The deflections were obtained by means of a No. 36 bright steel wire stretched at constant tension between points at each end of the beam, and approximately along the middle of the depth of the beam. This wire passed in front of a paper scale attached to the side of the beam at the middle of the span. The scale was pasted to a mirror, and by reading the intersection of wire and scale when the wire and its reflection were coincident, errors due to parallax were practically avoided. The mirror was secured to a piece of pine board which was nailed to the beam. By this apparatus deflections of 0.01 inch were readily observed.

The accompanying table summarizes the results of the test. In the column of "Applied Loads," the loads actually placed on platforms, plus the weight of platforms, hangers, etc., are stated. The column of "Load Considered," is the sum of the applied loads, and the weight of the beam. The latter weight was computed, estimating concrete to weigh 146 lbs. per cubic foot. The column headed "Equivalent Uniform Load," is derived from the bending moment and includes the weight of beam, as in a caisson the weight of the side walls is zero so far as the bending moment is concerned. The quantities given in column headed "Strength per sq. inch," are from actual tests of the materials employed in making the beams; in the case of the concrete, the quantity opposite each beam is the average obtained from crushing three 6-inch cubes 10 days old, made from the same batch as the corresponding beam. The quantities given in columns headed "Calculated Stresses per sq. in.," were obtained by means of the following formulae given in Proceedings of Am.

Soc. C. E. February, 1909, page 117 (Certain typographic errors are corrected below).

$$k = \sqrt{2n \left(p + p' \frac{d'}{d} \right) + n^2 (p + p')^2 - n (p + p')}.$$

$$z = \frac{\frac{1}{3} k^3 d + 2 p' n d' \left(k - \frac{d'}{d} \right)}{k^2 + 2 p' n \left(k - \frac{d'}{d} \right)}.$$

$$j = \frac{d-z}{d} = \text{approximately } \frac{d-d'}{d}$$

$$f_c = \frac{6M}{bd^2 \left[3k - k^2 + \frac{6p'n}{k} \left(k - \frac{d'}{d} \right) \left(1 - \frac{d'}{d} \right) \right]}$$

$$f_s = \frac{M}{p j b d^2} = n f_e \frac{1-k}{k}$$

$$f's = n f_c \frac{k - \frac{d'}{d}}{k}.$$

$$v = \frac{V}{b j d}.$$

$$u = \frac{V}{j d \Sigma o}.$$

In which:

f_s = tensile unit stress in steel.

$f's$ = compressive unit stress in steel.

f_c = compressive unit stress in concrete.

E_s = modulus of elasticity of steel

$n = \frac{E_s}{E_c}$ =

E_c = modulus of elasticity of concrete

M = moment of resistance or bending moment in general.

b = breadth of beam.

d = depth of beam to center of tension steel.

d' = depth of beam to center of compression steel.

k = ratio of depth of neutral axis to effective depth, d .

z = depth of resultant of compressive stresses below top of beam.

j = ratio of lever arm of resisting couple to depth, d ; or, *approx-*

mately $j = \frac{d-d'}{d}$

p = ratio of tension steel (not percentage).

p' = ratio of compression steel (not percentage).

V = total shear.

v = shearing unit stress.

t = diagonal tension unit stress.

u = bond stress per unit area of bar.

Σo = sum of the perimeters of all bars.

For the purpose of computation, the moduli of elasticity of steel

and concrete were assumed to be 30,000,000 and 1,250,000, respectively; hence $n=24$.

As the reinforcement is equal, top and bottom, $p=p'$.

It was assumed that when the maximum diagonal tension was developed there was no horizontal tension in the concrete, and hence $t=v$.

APPENDIX III.

DESCRIPTION OF ALGOMA CAISSON WORK

BY MR. L. E. LION, U. S. ASST. ENGINEER.

M. AM. Soc. C. E.

The river and harbor act of March 2, 1907, contained the following item: "Improving harbor at Algoma (Ahnapee), Wisconsin, by the construction of an outer harbor with a depth of sixteen feet of water, \$40,000; Provided, that the Secretary of War may enter into a contract or contracts for such materials and work as may be necessary to complete such project, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate \$100,000, exclusive of the amounts herein and heretofore appropriated."

During May and June, 1907, a survey and examination, including many borings, were made on which to base a design for Algoma harbor. After considerable study of the data obtained, it was decided to build a small outer harbor in Lake Michigan, immediately south of the then existing harbor entrance, as shown on Plate IV.

The project embraced 511.7 linear feet of reinforced concrete breakwater, 733.7 linear feet of pile pier, 200 linear feet of plank cribs and about 115,000 cubic yards of dredging. In addition 550 linear feet of the old south pier were to be removed, and the north pier was to be repaired by the renewal of four courses of timber in the superstructure.

The cost of this work, including supervision and contingencies was estimated at \$142,000, which was slightly in excess of the amount available, but there was a small balance on hand for maintenance under which the repairs to the north pier properly came.

The portion of the breakwater most exposed to the action of waves consisted of 511.7 linear feet of reinforced concrete breakwater, made up of twenty reinforced concrete caissons of 1-2-4 concrete resting on a pile foundation and surmounted by a solid concrete superstructure. Each caisson was 24 feet in length, 15 feet wide, and 12 feet 4 inches in height, with sides and end walls 12 inches in thickness and bottom 20 inches in thickness, 16 of which were of concrete and 4 of timber studded with 8-inch spikes. A transverse wall 10 inches in thickness, divided each caisson into two cells. The caissons were reinforced with deformed bars of the Johnson type made of mild steel and were designed to withstand water pressure from the out-

side while afloat and to retain the filling after being put in place. Reinforcement was also provided to give ample strength to resist the stresses of launching, handling, or unequal bearing on the foundation.

The reinforcing steel in the walls was proportioned according to the method given by Mansfield Merriman in "Mechanics of Materials," 10th Edition, page 286, the steel being assumed to carry all of the tension and compression while the concrete was assumed to act only as a spacing medium and bear the stresses which would be carried by the web of a girder. While this method gives an excess of steel it was thought advisable to use it on account of the early age at which the concrete would receive its launching stresses. The steel in the bottom of the caissons was proportioned according to the method given in Taylor and Thompson's "Concrete Plain and Reinforced," first edition, page 563. In order to provide for possible errors in the cutoff of foundation piles, sufficient steel was also placed in the caissons to enable them to carry safely their own weight and load due to filling, if supported only at the ends or at the center.

A foundation of eighteen piles supported each caisson, the piles being cut off eleven feet, four inches below datum. Riprap stone was used for filling the caissons to within four feet of the top, the upper four feet of the filling being of 1-5-10 concrete. In order to facilitate correct sinking, two guide timbers 12 in. by 12 in. and 11 feet and 4 in. long, were bolted to each end of the caissons, making an interval of 1 foot between each caisson. This interval was afterwards filled with small stone, and capped with a slab of 1-3-5 concrete 1 foot in thickness.

The superstructure which topped the caissons was built of 1-3-5 mass concrete, and was carried to an elevation of 4 feet above datum. It covered 9 feet 6 inches of the 15 feet of width of caissons and was approximately trapezoidal in cross-section, having a slope of 1 on $2\frac{1}{2}$ on the lake side, and an almost vertical face on the harbor side. The caissons were protected by riprap on both the lake and harbor sides to within 4 feet of datum, large stone being used on the outside. A cross-section of the breakwater and a horizontal section of one of the caissons are shown on Plate V.

In answer to an advertisement for proposals for building the entire breakwater, the following bids were received. All timber, except caisson bottoms and piles, together with steel reinforcing bars were to be furnished by the United States and were therefore not included in the prices bid:

Thos. H. Smith, Sturgeon Bay, Wis.	Bid: \$50,122.50 on Concrete Breakwater only.
Great Lakes Dredge & Dock Co., Chicago, Ill.....	\$120,166.00
Adolph Green, Green Bay, Wis.....	110,380.50
Greiling Bros., Green Bay, Wis.....	104,057.00
Estimated cost	92,490.00
Amount available for this part of the work.....	94,000.00

The lowest bid was that of Greiling Bros. of Green Bay, Wis., which was \$11,567 in excess of the estimated cost, and \$10,057 in excess of the amount available after making due allowance for contingencies, supervision, materials to be furnished, and repairs to the north pier.

All bids were therefore rejected and it was determined to execute the work by hired labor. Steps were immediately taken for the purchase of the necessary tools and materials and to begin work as soon as weather conditions permitted.

Contracts for piles, timber and reinforcing bars had previously been entered into, to supply the contractor under the proposed contract.

The United States yard at Kewaunee, Wis., was selected as the most advantageous point at which to build the reinforced concrete caissons. At Algoma, Wis., the small depth of water and rock bottom inside of the harbor would have made launching caissons hazardous, and the fact that an equal number of caissons were needed for Manitowoc, Wis., made it evident that one plant to serve both Algoma, Wis., and Manitowoc, Wis., was more advantageous to the United States, than the establishment of two separate plants. Moreover, the United States owned a yard and warehouse at Kewaunee, Wis., where the construction of a permanent set of ways for hauling floating plant out of water was a desirable and necessary improvement for the maintenance of floating property. The water bordering on Government yards at Kewaunee is free from waves and currents, being on an old branch of Kewaukee river, and while the depth of water was not sufficient, a small amount of dredging made it ample. Kewaunee, Wis., is 12 miles south of Algoma, Wis., and 30 miles north of Manitowoc, Wis.

Work was begun at the yard on March 12, 1908, by the erection of a warehouse for the storage of cement. As the weather moderated work was gradually extended to the launching ways and forms for the caissons. All parts of the plant were installed by June 1, 1908, when the actual construction of caissons was begun.

LAUNCHING WAYS.

Three sets of launching ways were built for launching the reinforced concrete caissons. Each set of ways was 24 feet wide and 103 feet long, terminating under water at a depth of 6 feet below datum. There was a clear space of 10 feet between each set of ways. The piles supporting the ways were spaced to sustain a load of 15 tons to the pile, and were driven in bents of three piles. Each bent was capped with 12 in. by 12 in. timbers, 24 feet long. Three longitudinal timbers, 12 in. by 12 in., placed at an inclination of 1 on 10, formed each set of fixed ways. The caps were drift-bolted to the piles, and the fixed ways to the caps. The gage of the ways in the clear was 22 feet. The computed weight of each caisson was 119

tons; the area of sliding ways on the fixed ways was 45 square feet, making the load per square foot 2.65 tons.

The cost of the launching ways was \$3,684.52, which includes all labor and materials.

FORMS.

The forms were made in three distinct parts, the outside forms, the inside forms or core, and the trusses for holding the forms rigidly in place.

All lumber used was Oregon fir, dressed on all sides and edges. The lagging was of 2-inch boards, placed horizontally and bolted to 2 in. by 6 in. studding. Each side and end of the outside form was made in three sections to facilitate handling and placing. In the core forms each side and end was made in one piece. Six by six struts were used inside of the core for bracing, and twenty trusses, ten to a side, each truss stiffened with a $\frac{7}{8}$ in. iron rod and turnbuckle for tightening, were used for stiffening the outside forms. The trusses were so built and placed that through the use of 3 in. by 12 in. boards on edge across the ends, the entire outside form was rigidly girdled and held in place. One set of trusses and braces served the three forms. The accompanying photographs will give a clear idea of the trusses and forms.

Three sets of forms were built at a total cost of \$1,839.57. After completing the Algoma caissons these forms were slightly modified and used in the construction of 22 Manitowoc caissons. They are still in serviceable condition.

PLANT.

The launching ways, previously described, formed of course the most important part of the plant. In the rear of the launching ways a traveling derrick of 3-tons capacity with a 50-foot boom, ran on a track of 28-foot gage parallel to the back of the ways. This derrick was so placed that it could handle the forms, steel, and concrete on any of the ways. A number "2½ Smith" concrete mixer was mounted behind the derrick so as to be easily moved by means of rollers on longitudinal timbers placed between the derrick tracks. The mixer engine received steam from the derrick boiler. In the rear of the concrete mixer and secured to the same frame as the mixer was a small auxiliary derrick which was used only for handling the broken stone and sand, which it lifted in skips from small flat cars, and dumped into a hopper immediately over and behind the mixer. This derrick was operated by a Manila line running to a winch head on the hoisting engine of the traveling derrick.

A double narrow-gage track ran from the storage pile of aggregates to the mixer. The materials were shoveled into and proportioned in metal skips on flat cars. Two cars were used, one on each track, and were propelled by the men who loaded them.

A temporary warehouse for the storage of cement, 25 feet by 50 feet, was built parallel to the tracks so as to be near the mixer.

Water was supplied to the entire yard by means of a 2½ H. P. gasoline engine, and a 5 in. by 5 in. double acting belt driven force pump, which pumped the water into a galvanized iron tank mounted on a trestle over the pump house. A 2-inch water main distributed the water to the mixer, hoisting engine and other parts of the yard.

Besides the above plant, a blacksmith shop, cement testing laboratory, office and warehouse for miscellaneous storage were already on the ground and were used on this work. Many small tools were also purchased for the work.

The entire cost of the plant and installation, exclusive of the cost of the launching ways and cement warehouse, was \$5,778.27. The cement warehouse cost \$521.40.

.. SETTING UP FORMS AND PLACING OF STEEL.

The forms were set up over the launching ways. Blocks about 12 in. by 12 in. by 6 in. which were easily split with splitting wedges, were placed on the pile caps of the ways, in order to secure a level support for the 12 in. by 12 in. timbers on which the bottom and forming were placed. Short blocks, capable of being easily split with wedges, were used as this was the means employed for lowering the caissons on the sliding shoes at the time of launching.

After carefully leveling the timbers on which the form was to rest, 4 in. by 12 in. timbers 24 feet long, through which 8 in. wire spikes had previously been driven, were placed in position on the supporting 12 in. by 12 in. timbers to form the bottom of the caissons. The 8-inch spikes became firmly imbedded in the concrete, thus binding securely the wood bottom and the concrete.

The lower layer of reinforcement was now put in place. The rods were kept above the wood bottom by small rods running perpendicular to the reinforcement and kept at the correct elevation by means of pebbles.

In later work it was found advantageous to place a layer of building paper over the wood bottoms in order to prevent the escape of mortar and cement from the concrete through the cracks in the bottom. This escape of mortar, while not great, seemed to render the bottom porous in places and caused some leaks, which, while not serious, were annoying. The use of the building paper improved the water-tightness of the bottom.

Iron brackets for supporting the core were now put in place. These were made of ¾ in. by 1½ in. mild steel bent into the shape shown in Fig. 3, Plate VI.

Eight of these brackets supported each core. Sixteen constituted a set as there were two cores to a caisson. The brackets remained in the concrete.

The brackets being placed, the cores were now erected, together with their inside braces, which consisted of eighty struts of 6 in. by 6 in. Oregon fir. After the cores were erected and in proper position, beams of 4 in. by 6 in. timber were placed across the top of the

cores and bolted thereto, for the purpose of suspending the wall reinforcement.

When the cores and bracing inside of the cores were in place, the upper layer of reinforcement in the bottom was put in position. This rested on bars suspended from the core braces at right angles to the direction of the reinforcement. Where the reinforcing bars crossed the supporting bars, these were wired together with No. 20 wire, so as to prevent displacement in depositing concrete.

While the bottom, core forms, and bottom steel were being put in place, the reinforcement for the walls was being prepared for the work by threading through holes punched to the proper spacing in steel flats, $1/16$ in. by 2 in. By using three spacing flats for each vertical row of bars, a unit of reinforcement was formed which was readily lifted into place by the derrick and suspended from beams supported by the core. The upright reinforcing bars were wired to the horizontals before the unit was bolted in place. All of the reinforcement in the walls was put in place in this manner, except the short bars at the corners. These were wired to the horizontal bars in place.

All of the steel now being in place, the outside forming was erected, the four walls being brought up simultaneously. This forming was held in place by ten sets of trusses and boards on edge which locked around the form, and held it rigidly in place and prevented yielding as the trusses were so designed as to take up all of the pressure which was brought to the outside forms by the wet and unset concrete. All examination of the photographs (Views 1 to 4 inclusive) will make clear the form construction and method of bracing the forms.

METHOD OF MOLDING.

It was endeavored to mold each caisson at one continuous operation, in order to secure a perfect monolith and thus lessen the danger of leaks. All of the caissons were successfully molded at one operation, except the first one, which required two days on account of a change which was found necessary in the arrangement of the plant. No leaks developed in the caisson which was molded in two days.

A temporary platform with two hatches, one in the center of each core, was placed over the core forming. The concrete mixed to a very wet consistency was dumped through the hatches into the bottom and near the edges of the platform in molding the walls. The concrete was shoveled from the platform into the walls and puddled thoroughly by means of long sticks. Puddling of the bottom was effected by laborers working inside of the core. The bottom was placed first, and then the sides, ends and cross-walls were brought up simultaneously.

The aggregates were shoveled into skips resting on small flat cars at the stock pile. The cars were then run over the narrow gage track to the derrick in the rear of the mixer which raised the skips and dumped them into the mixer hopper. The cement was added in

the hopper. Each batch consisted of 2 bags of cement, 4 cubic feet of crusher dust and 8 cubic feet of 1 in. broken stone. A barrel so arranged as to measure the water used in mixing the concrete, rested on the platform above the mixer, and was operated by a lever by the man on the mixer platform. The concrete was given about 14 turns in the mixer, and then dumped directly into a bottom dumping bucket, which was handled by the traveling derrick.

An average of 281.6 bags of cement were used in each caisson, making 1.347 barrels of cement to every cubic yard of concrete.

As a rule seven hours were required for molding a caisson, or 7.46 cubic yards per hour.

The quantity and cost of materials in a caisson averaged as follows:

Stone and Sand, 52.21 cu. yds., at \$1.25.....	\$ 65.26
Cement, 70.4 bbls., at \$1.15.....	80.96
Reinforcing Bars, 12,967 lbs., at 1.92 cts.....	248.97
Bolts	15.59
Timber	66.65
Spikes and Wire.....	4.54
Brackets	76.53
Flats	69.82

• Total.....\$628.32

The force employed in molding was usually as follows:

1 Foreman at \$120 per month.....	\$ 4.00
1 Engineman at \$80 per month.....	2.67
1 Fireman at \$60 per month.....	2.00
1 man operating small derrick, at \$2.25 per day.....	2.25
2 men carrying cement, at \$1.75 per day.....	3.50
1 man on mixer platform, at \$2 per day.....	2.00
1 man dumping mixer, at \$2.....	2.00
6 men at stock pile and transporting aggregates, at \$1.75 per day.....	10.50
2 men placing concrete in forms, at \$2.25 per day.....	4.50
6 men puddling, at \$1.75 per day.....	10.50

22 men.....\$43.92

This same force was employed in setting up forms, placing steel, and all other work pertaining to caisson construction.

REMOVAL OF FORMS.

The inside and outside bracing were removed when the concrete was 24 hours old, and the forms whenever convenient, after the concrete was 48 hours old. No difficulty was experienced in the removal of forms, nor did any material adhere to the forms so as to leave a disfigured surface, although they were not coated with any preparation.

August, 1909

WATERPROOFING.

Within two days after the removal of the forms, the outside of the caissons was given a wash of thin grout made of neat cement. This wash was applied and rubbed well into the surface of the concrete with a whitewash brush. After the cement had dried, two coats of the following wash were applied:

One pound of concentrated lye and five pounds of alum were added to 2 gallons of water, care being taken that every particle was dissolved. This constituted the "stock." To one pint of the "stock" was added 10 pounds of cement, and water until the mixture was of such a consistency as to spread easily on the walls with a brush. Usually 1 pint of stock was put into a 12-quart bucket, and 10 pounds of cement stirred in with enough water added to fill the bucket. This recipe was obtained from the Report of the Chief of Engineers, 1902, Part 3, page 2,482, in which it is described by Assistant U. S. Engineer G. B. Hegardt.

With the small heads of water of 9 to 10 feet against the caissons when afloat, no difficulty was experienced in obtaining water-tight walls, and it is thought that the walls would have been impervious without the application of any preparation. As the cost of this mixture was very small, it was put on the caissons as a precaution against leakage.

All caissons were tested for leaks before applying the waterproofing wash by pumping about 6 feet of water into each one. This was syphoned out before the application of the wash.

LAUNCHING.

Before launching, temporary timber decks were placed on the caissons for the purpose of excluding water during towing and launching. These were made in four sections of 2-in. Oregon fir, with all seams tightly calked and provided with ring-bolts for lifting the sections into and out of position. In order to shorten the span of the deck planks, and add to their rigidity and supporting power, 6 in. by 6 in. timbers were placed longitudinally across the inside of the caissons near the top, and rested on the imbedded timbers and on the cross-wall. These timbers were supported in the middle by 6 in. by 6 in. columns, resting on the caisson bottom. For convenience in removing, lag screws were used for fastening the deck to the imbedded timbers. Two small hatches were placed in each deck for purposes of inspection. Before launching or towing the hatches were fastened down securely, and all joints around hatches and between the concrete and deck were carefully calked. A total of four decks sufficed for the entire work.

The 12 in. by 12 in. guide timbers shown in the drawings were bolted to the caisson ends, bolts having been imbedded in the concrete for this purpose.

Three sliding shoes for launching were used under each caisson

at the time of launching. These were made as shown on Plate VII, with an oak sliding surface and Oregon fir filling above. The outside shoes were provided with ribbands on the inside only. The middle shoe had no ribbands at all. The shoes were lubricated with beef tallow just before launching and then driven tightly under the caisson bottoms. An inclined shore placed against the sliding shoes in front of the caissons, together with a tripping lock on each side of the ways, held the caisson and sliding shoes in place while the weight of the caisson was being transferred from the stocks to the sliding shoes.

In order to take the load off the stocks, the small blocks supporting the 12 in. by 12 in. timbers on which the caisson rested, were split with steel splitting wedges, thus allowing the caisson gradually to settle upon the shoes. The small blocks having been cut out, the



VIEW 5.

Reinforced Concrete Caisson for Algoma Breakwater, being launched.

12 in. by 12 in. timbers or stocks were removed, and the caisson was ready for launching (see Plate VII).

The ways having been freshly greased with tallow, men were stationed at the shores and tripping keys. At a signal previously agreed upon, the shores were knocked out with sledges, and at a second signal the tripping device on each side was tripped, releasing the caisson, which started by its own weight. All of the caissons moved readily as soon as released and traveled the entire length of the ways without binding in any way. The velocity of travel averaged 8.6 feet per second. The launching of a caisson is illustrated in View 5.

August, 1909

As the ways terminated at a depth of six feet below water, and the draft of the caissons was about 9.7 feet, the caissons tilted and submerged themselves on leaving the ways, as they had a fall of about 3.7 feet in water. However, they righted themselves immediately and came to the surface on an even keel. Every launching was satisfactory in all respects.

A caisson having been launched it was prepared for towing by wrapping around it a girdle chain to which the towing hawser was made fast.

The small fishing tug "Southern Cross" towed all of the caissons from Kewaunee, Wis., to Algoma, Wis., a distance of 12 miles from pier to pier. This boat is 56 feet in length, and of 25 gross tonnage. Her engines are 10 in. by 12 in., and her boiler carries 100 pounds of steam.

The time of towing was usually from 6 to 7 hours or at the rate of a little less than 2 miles per hour. As a rule the tug took but one caisson at a time, but on two occasions she took two at a tow, and handled them as well as one, although the time of towing was a little greater.

The cost of towing was \$20. per caisson at first and later \$23. per caisson, which included the return of the temporary decks. As the total cost of towing was \$442, the cost of towing per cubic yard amounted to \$0.423.

STORING.

The caissons were stored afloat at Algoma until they were needed in the work (View 6). The decks were removed as soon as received and returned to the molding plant at Kewaunee, where they were used over and over. No trouble was experienced in keeping caissons afloat for weeks at a time, their impermeability being such that no pumping whatever was required.

BREAKWATER FOUNDATION.

The foundation consisted of piles driven to a firm bearing and when practicable to rock. Piles 40 feet long were used and were cut off at a depth of 11 ft. 4 in. below datum. As the piles generally stood about 4 feet above datum when the desired resistance was attained, a penetration of about 25 feet was obtained. The space around the piles was filled with riprap stone which was carefully leveled off by a diver about 9 in. below the pile tops.

A swinging "A" shaped saw-frame having a radius of 16 feet, and pivoted above water on the pile being cut was used for cutting off the piles. An ordinary cross-cut saw was fastened to the lower end of the frame, and the saw drawn back and forth by men on rafts hauling on lines attached to the lower end of the saw-frame. Errors in cutting off which were lower than the desired elevation were corrected by placing shims of the proper thickness under an iron casting with suitably roughened upper and lower surfaces designed

to equalize the bearing and introduce friction (see Fig. 2, Plate VI). The error of cut-off was intentionally kept low, and it was not found necessary to re-cut any piles on account of their being too high. The floating stages on which the men worked were made of 12 in. by 12 in. by 20 ft. timbers held together by scantlings spiked across their tops.

SINKING AND FILLING CAISSONS.

About 100 feet of foundation were prepared at a time, and when this was in readiness, four caissons were sunk. The sinking was effected by syphoning water into the caissons by hanging 2 in. syphons over the wall (Views 7 and 8). In order to start a syphon it was first filled with water and a wooden plug having a handle was inserted in each end. The two plugs were released at the same time and the flow of water thus started. From twelve to fourteen syphons were used to expedite the sinking.



VIEW 6.

Reinforced Concrete Caissons afloat in Algoma Harbor.

Each caisson was put into exact position by securing one end to the previously sunk caisson and holding the farther end precisely in place by means of light blocks and tackle. An instrument-man with a transit observed the position of each caisson while being sunk and gave the necessary signals for keeping it on line. No difficulty was experienced in holding caissons on line or sinking in the desired position. Whenever a caisson was misplaced it was easily floated again by pumping out some of the water. A caisson having been sunk it was filled with riprap stone to within four feet of its top (View 9). It was generally found practicable to sink and fill with riprap four caissons in a day. The upper concrete filling was deposited soon after sinking. A layer of burlap was spread over the riprap to prevent mortar from running into the interstices between the stones, and the concrete placed on this (View 10). Two forms

for manholes were placed in each caisson, one in each compartment as shown in the drawing. Before concreting, the water in the caissons was pumped down below the level of the riprap, so that the filling was deposited in air. The surface of the filling was given a smooth finish where no superstructure came over it. Under the superstructure the surface was left rough so as to bind more effectively with the superstructure which was subsequently added.

Before the caissons were sunk, eight pile tops were placed in the caissons in a vertical position to act as supporting pillars for the concrete filling in case the riprap filling should settle away from the concrete.



VIEW 7.

Reinforced Concrete Caissons for Algoma Harbor.

Covers of reinforced concrete were molded in the manhole tops to close the openings (see Fig 1. Plate VI).

A mixer mounted on a scow was used for mixing the concrete for the filling and for the superstructure. This mixer was set at an elevation which permitted dumping the mixed material directly from the mixer into a chute from which the wet mixture flowed into the work.

INTERVALS BETWEEN CAISSONS.

The intervals 12 inches in width, between caissons were filled with small stone to within one foot of the top, and then covered with a 3 in. by 12 in. board, on which a filling of 1:3:5 concrete was

placed. This filling was brought up to the top of the caissons, and given a finished surface the same as the caisson filling.

SUPERSTRUCTURE.

A superstructure of 1:3:5 concrete of the form and dimensions shown on the drawings was built to an elevation of 4 feet above datum. The superstructure was built in sections 25 feet in length, the joint between sections being made coincident with the center of the interval between caissons. Alternate isolated sections were first molded and then the intermediate sections, a layer of building paper being placed between each section to provide against temperature changes. The concrete in the superstructure was deposited from a mixer on a scow in the same manner as the concrete filling (Views 11 and 12).

COST OF WORK.

The plant purchased for the manufacture of the concrete caissons, not counting as plant the launching ways or the cement warehouse, amounted to \$5,778.27, distributed as follows:

3-ton traveling derrick and installation of same.....	\$2,283.05
Small derrick and installation of same.....	59.03
Concrete mixer; Smith No. 2½ and installation of same..	860.63
Narrow gage railway and 4 flat cars.....	344.78
Gasoline engine, pump tank and pipes for water supply...	429.33
Buckets and skips.....	233.75
Cement testing apparatus.....	387.05
Timber and blocking in yard.....	207.00
Towing equipment.....	41.26
Shed for steel.....	13.57
Telephone and office equipment.....	49.36
Clearing yard	94.97
Small tools	145.12
Miscellaneous supplies	629.37
	\$5,778.27

The three sets of launching ways cost \$3,684.52, made up of the following items:

Piles	\$1,202.40
Timber	715.80
Excavating and dredging	444.11
Labor and miscellaneous supplies.....	1,322.21
	\$3,684.52

A temporary warehouse for storing cement, 49 ft. by 24 ft. was erected at a total cost of.....\$521.40

Three sets of forms were used for the Algoma and Manitowoc caissons. The cost of these was \$1,839.57, distributed as follows:

Lumber	\$ 532.60
Rods and turnbuckles	26.55
Bolts	109.76
Iron plates	23.10
Mill work	53.79
Labor	993.77

\$1,839.57

As there were 1.045 cubic yards of concrete in the Algoma caissons and those for Manitowoc will amount to 980 cubic yards, a



VIEW 8.

Reinforced Concrete Caissons at Algoma Harbor—filling and sinking with water, by syphons.

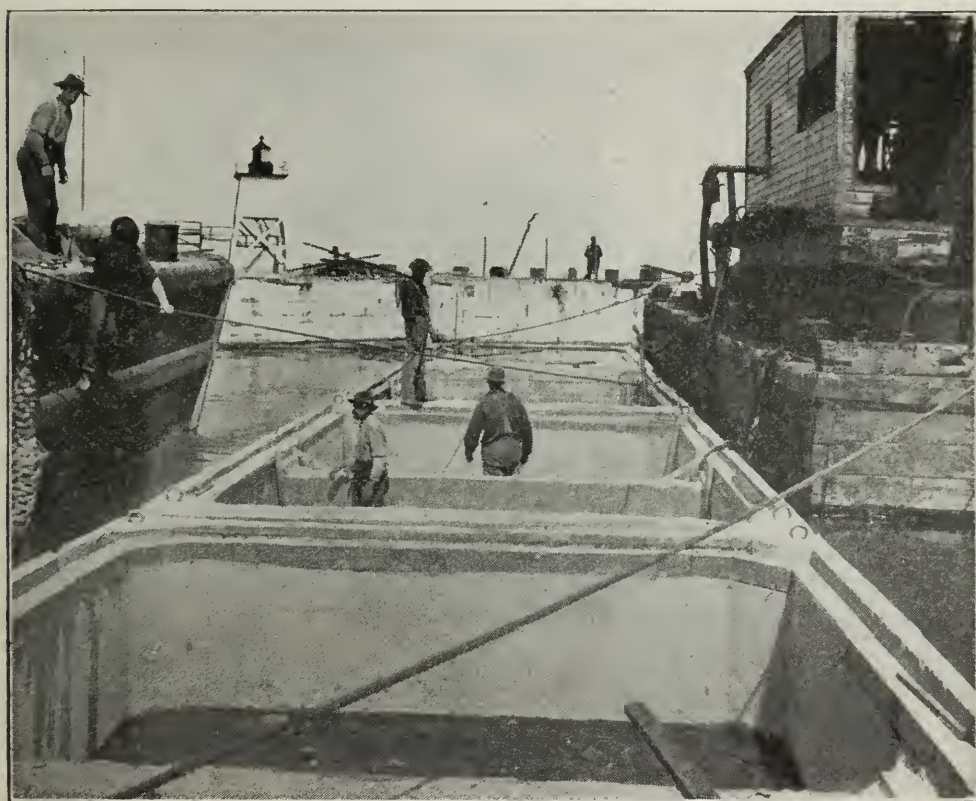
total of 2,025 cubic yards will have been moulded in the forms, making the cost of forming \$0.908 per cubic yard.

In the following cost analysis, the charge to the work on account of plant is based on the depreciation of same and the interest on the investment, as the plant is portable and has considerable value for future work. Launching ways and warehouse as stated before are not here included in the item plant, as they are not portable and must be treated differently. Credit is taken for the present value to the United States of the launching ways, which is estimated at

\$2,165.77, making the amount chargeable to the Algoma and Manitowoc caissons \$1,518.75. The cement warehouse is assumed to have no present value and is charged entirely to the Algoma and Manitowoc caissons. It is probable that a contractor doing similar work would charge the entire cost of the launching ways to the work for these would be of no value to him on the completion of the job, unless he could then find a purchaser for them.

The amount chargeable on account of the plant is as follows:

Depreciation, 10% of cost.....	\$577.83
Interest on cost, 6% for 12 months.....	346.70
	\$924.53



VIEW 9.

Reinforced Concrete Caissons—in place, Algoma Harbor—and partly filled with rip-rap stone.

The amounts chargeable to every cubic yard of concrete in the Algoma caissons will therefore be as follows:

On account of cement warehouse, $521.40 \div 2025 = \$0.257$

On account of launching ways, $1518.75 \div 2025 = \$0.750$

On account of plant, $924.53 \div 2025 = \$0.457$.

August, 1909

The following is the cost of the materials entering into the construction of the twenty caissons for the breakwater, as well as the cost of fuel, oils, and miscellaneous supplies:

Portland cement	\$1,619.20
Sand and stone	1,356.25
Nails and spikes	81.00
Bolts	224.28
Brackets for supporting core	153.05
Eye bolts	87.63
Oakum	6.90
Lubricating oils	29.32



VIEW 10.

Reinforced Concrete Caissons—Algoma Harbor, in place—with top filling of concrete, being placed.

Tallow	23.60
Gasoline	6.00
Coal	168.96
Reinforcing steel in caissons, 259,327 lbs.....	\$4,985.22
Flat bars for spacing.....	139.64
Wire	9.82
Timber in caissons and decks, 48,924 ft. B. M.....	1,332.90
Total	\$10,223.77

The cost of labor, including superintendence, was as follows:

Unloading cement	\$ 104.72
Setting up forms	1,221.75
Molding	1,160.35
Removing forms	242.43
Waterproofing	52.00
Testing	13.47
Repairing and cleaning forms	192.29
Launching	390.89
Care of caissons afloat	35.70
Handling crushed stone	198.88



VIEW II.

Reinforced Concrete Caissons—Breakwater at Algoma Harbor—top filling of concrete from mixer on scow—also showing manholes in concrete top.

Care of plant	202.72	
Miscellaneous	55.50	3,870.70
Unloading steel	90.65	
Placing steel	466.32	556.97
Transferring timber	45.60	
Spiking and framing floor timbers	160.56	
Placing decks, guide timbers, etc.....	677.70	883.86
Total		\$5,311.53

August, 1909

From the above it is computed that the total cost of labor and materials for 1,045 cubic yards of reinforced concrete in twenty caissons was as follows:

Concrete:

Materials	\$3,756.19
Labor	3,870.70
	\$7,626.89

Cost per cubic yard exclusive of warehouse, ways, plant, forms, steel and timber.....\$7,297

Reinforcing steel:

Materials	\$5,134.68
Labor handling and placing	556.97
	\$5,691.65



VIEW 12.

Finished—Reinforced Concrete, Caisson construction—Breakwater at Algoma Harbor.

Cost of steel, plus cost of placing in the work, per pound

\$0.0219

Timber:

Materials	\$1,332.90
Labor, handling and framing.....	883.86

\$2,216.76

Cost of timber and cost of placing in the work, per M. feet

B. M.\$45.31

A unit price of concrete exclusive of steel and the placing thereof, based on the foregoing, would be as follows:

	Per Cubic Yard
Cement warehouse	\$0.257
Launching ways	0.750
Plant	0.457
Forms	0.908
Labor and materials	7.297
	\$9.669

The cost of all labor and materials in the twenty caissons, exclusive of ways, warehouse, plant, and forms, was as follows:

Concrete	\$ 7,626.89
Reinforcing steel	5,691.65
Timber	2,216.76

$\$15,535.30 = \$776.77$ per caisson.

Including the above allowances for ways, warehouse, and forms, the cost for twenty caissons would be as follows:

Launching ways	\$ 783.75
Warehouse	268.57
Plant	477.57
Forms	948.86
Concrete	7,626.89
Reinforcing steel	5,691.65
Timber	2,216.76

$\$18,014.05 = \$900.70$ per caisson.

COST OF TOWING.

Cost of towing all caissons, 6 at \$20, 14 at \$23.....	\$442.00
Cost per cubic yard	0.423

The deck was removed from each caisson as soon as received and the pile tops which supported the upper four feet of concrete were then put in place. The total cost of this work was \$329.07, or \$16.45 per caisson.

COST OF PLANT FOR SINKING, FILLING, AND BUILDING SUPERSTRUCTURE. ..

The cost of the special plant acquired for the caisson work of the breakwater was as follows:

Concrete mixer, complete, and installation of same.....	\$1,450.75
Concrete tools	5.70
Saws and saw frames for cutting off piles under water....	37.00
Special tools, clam-shell bucket, paulin, etc.....	415.55
Scow repairs	48.38
Miscellaneous	229.50

\$2,186.88

Half value derrick and scow (other half charged to riprap) 1,650.00

\$3,836.88

All of the above plant is portable and will be treated the same as plant used for molding caissons in arriving at a charge for plant against every cubic yard of concrete:

Depreciation 10% of cost.....	\$383.69	
Interest on cost, 6% for 12 months.....	230.21	\$613.90

The second cement warehouse at Algoma, Wis., 49x24 feet, cost \$489.81, and the forms for superstructure cost \$221.02, while those for the manholes in the concrete filling cost \$24.22.

A total of 1,241 cubic yards of concrete was made and deposited in the concrete breakwater after sinking the caissons, 820 cubic yards of meagre 1:5:10 filling and 421 cubic yards of superstructure and intervals between caissons.

The amounts to be charged to every cubic yard of concrete for plant, warehouse, and forms are as follows:

	613.90	
Plant	<u>1241</u>	= \$0.495
	489.81	
Cement warehouse	<u>1241</u>	= 0.395
	221.02	
Superstructure forms	<u>421</u>	= 0.525
	24.22	
Manhole forms	<u>820</u>	= 0.030

The cost of all labor and materials in the 820 cubic yards of concrete filling was as follows:

Cement, 603 bbls., at \$1.15.....	\$ 693.45
Crushed stone, 821 cubic yards, at \$1.25.....	1,026.25
Handling cement	27.14
Handling crushed stone	257.78
Labor, mixing and placing	1,060.51
Fuel	155.17
	<u>\$3,220.30</u>

This places the cost of the meagre concrete at \$3.927 per cubic yard for the preceding items.

Including the cost of plant, forms and warehouse, the cost is as follows:

Plant	\$0.495
Warehouse	0.395
Forms	0.030
Labor and materials	3.927
	<u>\$4,847</u>

The cost of the labor and materials in the 421 cubic yards of concrete superstructure was as follows:

Cement, 532 bbls., at \$1.15.....	\$ 611.80
Crushed stone, 420 cubic yards.....	525.00
Handling cement	24.66
Handling crushed stone	151.23
Labor, mixing and placing.....	1,119.93
Fuel	79.77
	\$2,512.39

The cost of the concrete in the superstructure thus becomes:
 $2512.39 \div 421 = \$5.968$ per cubic yard.

Including proper charges for plant, forms and warehouse the cost becomes:

Plant	\$0.495
Warehouse	0.395
Forms	0.525
Labor and materials	5.968
	\$7.383

The piles in the foundation cost as follows:

Piles	\$2,481.60
Cast iron pile caps	176.40
Handling piles	64.52
Sharpening piles	149.15
Driving piles	239.57
Sawing off piles	358.47
Leveling piles and preparing foundation.....	449.63
	\$3,919.34

As there were 376 piles used in the foundation the cost per pile in the work, not including charge for plant, was as follows:

$$3919 \div 376 = \$10.42.$$

Allowing 10% depreciation on a \$2,000 pile driver and interest for 12 months at 6% on this driver, \$320 must be added to the above making the total \$4,239.34. The cost per pile driven then becomes:

$$4239.34 \div 376 = \$11.275.$$

The riprap consisted of large and small stone and some stone dredged from old work by the United States dredge. The cost was as follows:

Large riprap stone purchased, 1,572.45 tons, at \$1.19	\$1,871.22
Small riprap stone purchased, 3,825.52 tons, at \$0.98	3,749.01
Labor placing riprap on sides and caisson filling..	1,718.24

Total cost of stone purchased.....\$7,338.47

Riprap dredged for caissons, 1,231 tons, at 25 cents.	\$307.75	
Time of dredge in casting riprap, 16½ hours, at		
\$7.54	124.41	432.16

Total cost of riprap stone in place, exclusive of plant charge\$7,770.63

Plant used on riprap valued at \$1,650.00.

Depreciation on same, 10%	\$165.00	
Interest for 12 months, at 6%	99.00	264.00

Total cost of riprap stone in place, including plant charge..\$8,034.63

From the above the average cost in place of riprap stone purchased was \$1.44 per ton, exclusive of plant. This price is somewhat high, which is due to the fact that most of the stone had to be handled twice on account of the size and draft of the boats on which it was delivered.

The cost of the completed 511.7 feet of concrete breakwater from the above becomes as follows:

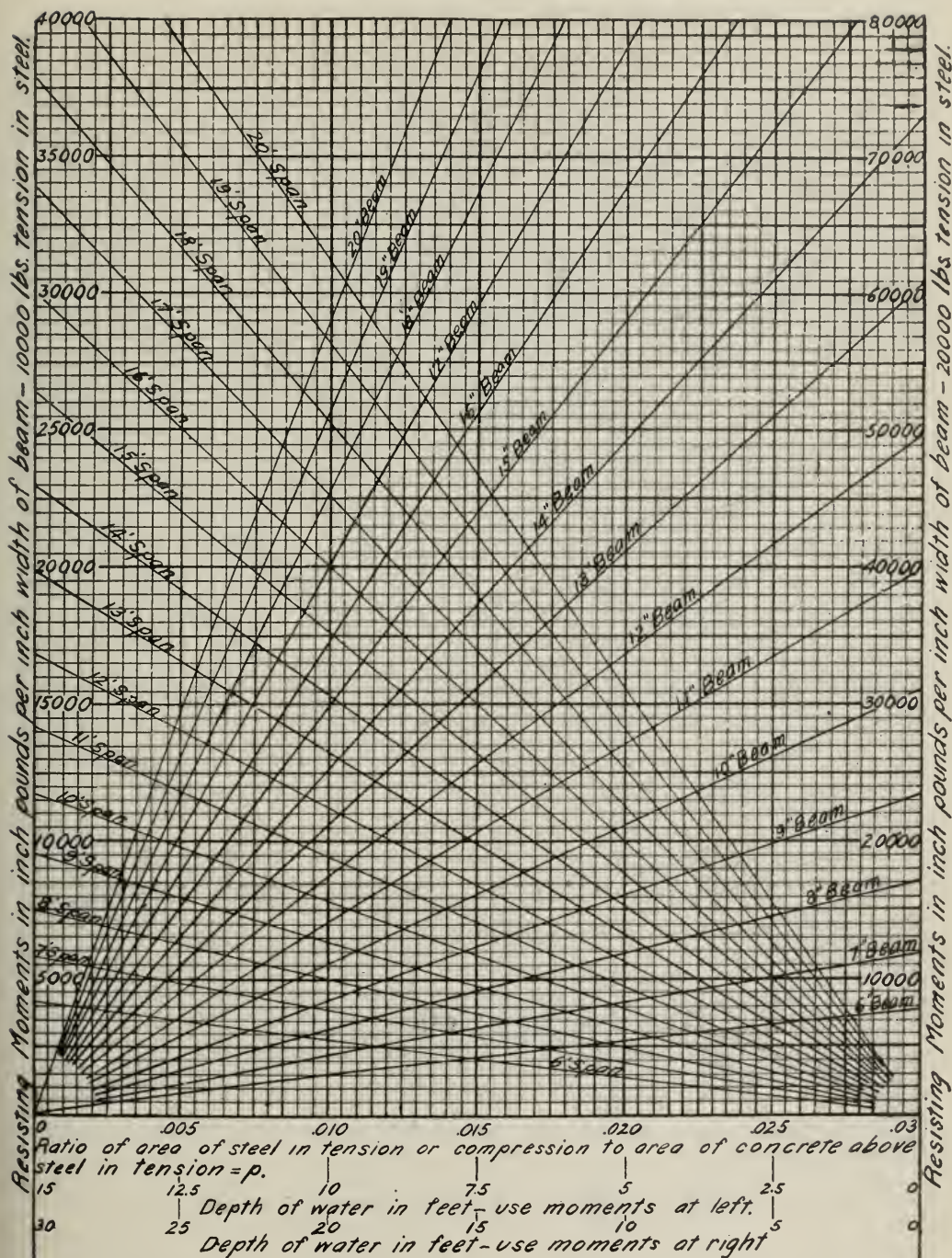
Caissons complete	\$18,014.05	✓
Towing caissons	442.00	✓
Removing decks and preparing caissons for sinking.....	329.07	✓
Setting ranges and preliminary work	71.81	
Piles and pile caps	2,658.00	✓
Handling, driving, cutting off, etc., piles	1,581.34	
Concrete filling, labor, materials and superintendence....	3,974.54	
Concrete superstructure, labor, materials and superintendence	3,108.24	
Riprap stone and handling same.....	8,034.63	✓
Towing with gasoline launch	323.25	
Miscellaneous supplies	181.65	
	<u>\$38,718.58</u>	

As there were 511.7 feet of concrete breakwater, the cost per linear foot of completed structure is:

$$38,718.58 \div 511.7 = \$75.67$$

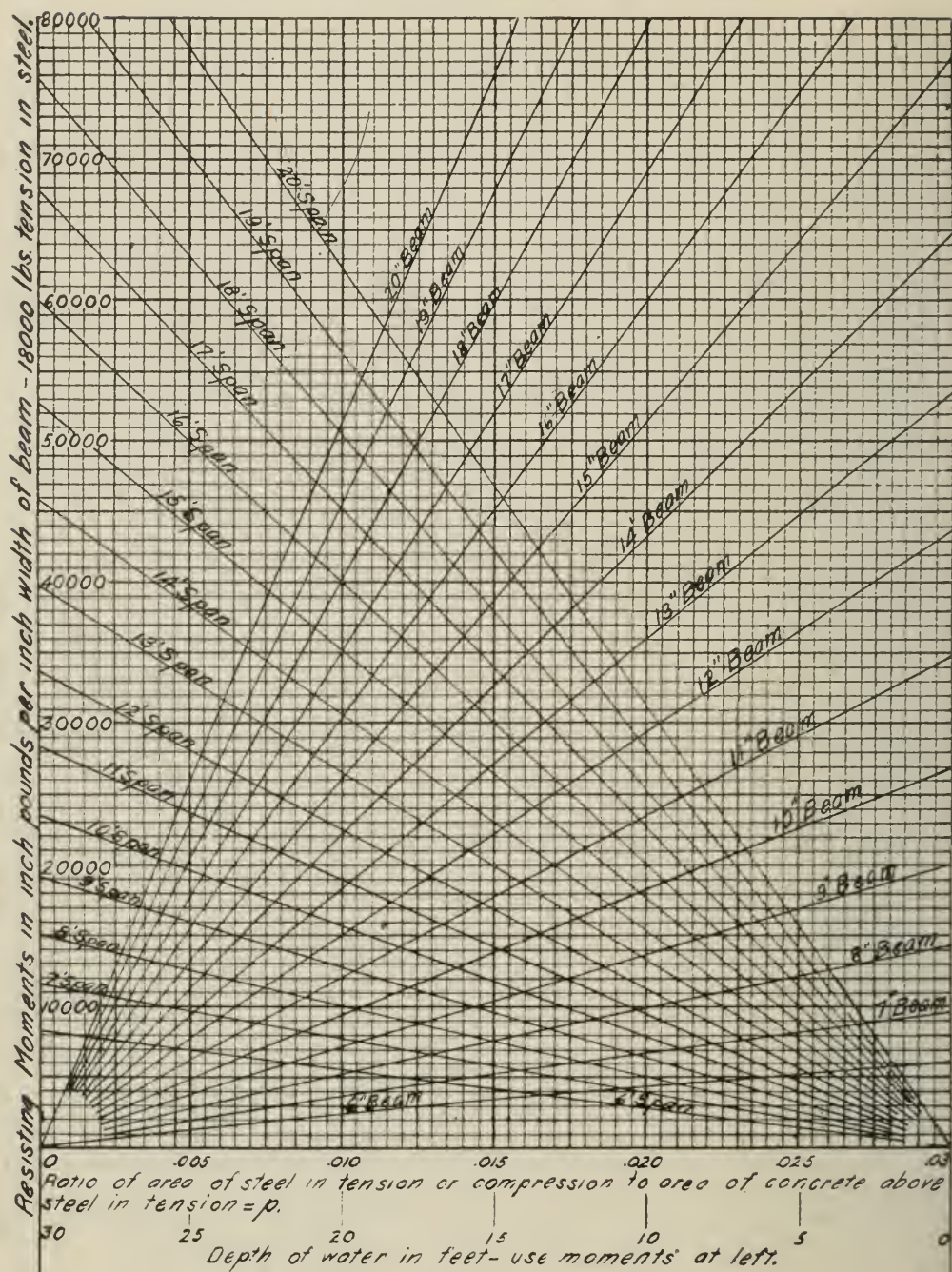
Estimated cost per linear foot	\$103.74
Actual cost per linear foot	<u>75.67</u>

Difference between estimated and actual cost.....\$ 28.07



MODULUS OF ELASTICITY OF CONCRETE = 3,000,000.

GRAPHICAL REPRESENTATION OF FORMULA FOR MOMENT OF RESISTANCE FOR REINFORCED CONCRETE BEAMS HAVING EQUAL REINFORCEMENT TOP AND BOTTOM; STEEL PLACED 2" FROM SURFACE OF BEAM; NO TENSION IN CONCRETE; TENSION IN STEEL = 10000 AND 20000 POUNDS PER SQUARE INCH.

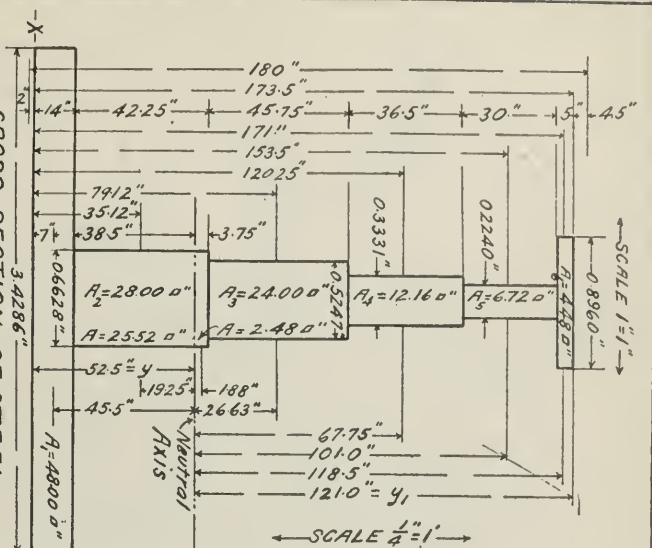


MODULUS OF ELASTICITY OF CONCRETE = 1,250,000.

GRAPHICAL REPRESENTATION OF FORMULA FOR MOMENT OF RESISTANCE FOR REINFORCED CONCRETE BEAMS HAVING EQUAL REINFORCEMENT TOP AND BOTTOM; STEEL PLACED 2" FROM SURFACE OF BEAM; NO TENSION IN CONCRETE; TENSION IN STEEL = 18000 POUNDS PER SQUARE INCH.

EMM
Plate II.

Vol. XIV. No. 1



CROSS SECTION OF STEEL PROJECTED INTO A BEAM

Position of Neutral Axis (Moments about X-X)

$$Y = \frac{(48 \times 7) + (28 \times 35.12) + (24 \times 73.12) + (12.16 \times 120.25) + (6.72 \times 153.5) + (4.48 \times 171) + (2.48 \times 180)}{48 + 28 + 24 + 12.16 + 6.72 + 4.48} = 123.32$$

Moment of Inertia of Cross Section of Steel about N.A.Xis.

$$I = \frac{1}{12} (34286 \times 171^3) + (48 \times 45.5^3) + \frac{1}{12} (0.6628 \times 38.5^3) + (2.552 \times 192.5^3) + \frac{1}{12} (0.6628 \times 37.5^3) + (2.48 \times 188^3) + \frac{1}{12} (0.5247 \times 45.75^3) + (12.16 \times 67.75^3) + \frac{1}{12} (0.3331 \times 36.5^3) + (12.16 \times 101.0^3) + \frac{1}{12} (0.8960 \times 5^3) + (4.48 \times 118.5^3) = 323,105 \text{ in}^4$$

$$\frac{1}{2} (0.2240 \times 30^3) + (6.72 \times 101.7^3) + \frac{1}{2} (0.8960 \times 5^3) + (4.48 \times 118.5^3) = 323,105 \text{ in}^4$$

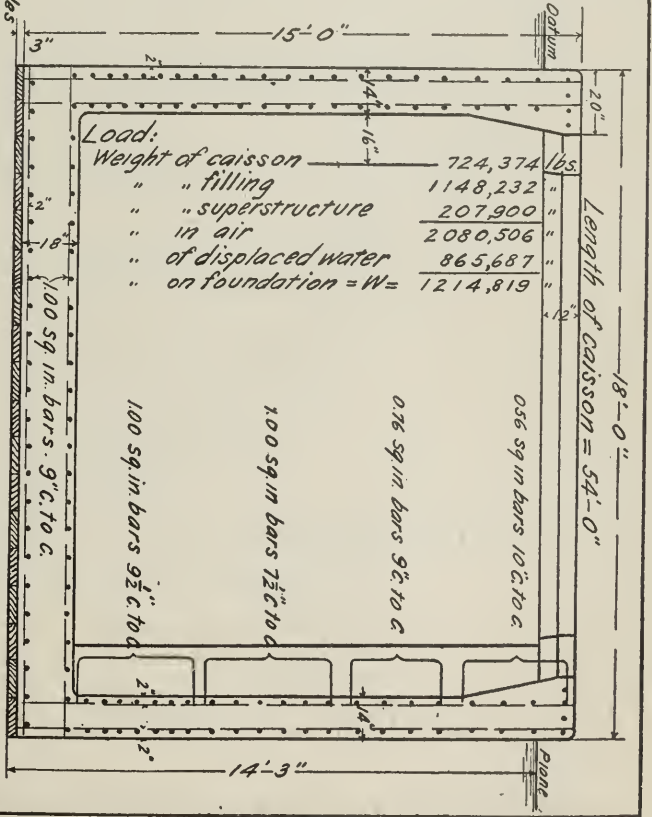
$$M_{max} = \frac{W}{8} (1214.819 \times 34.12) = 98,400.339 \text{ in lbs}$$

$$M_{max} = \frac{W}{8} (1214.819 \times 34.12) = 98,400.339 \text{ in lbs}$$

$$M_{max} = \frac{W}{8} (1214.819 \times 34.12) = 98,400.339 \text{ in lbs}$$

Area of steel in Side Longitudinal walls	Area of steel in Top and Bottom walls	Area of steel in Vertical walls	Area of steel in Total
4.48	4.48	0.8960	9.856
6.72	6.72	0.2240	13.664
12.16	12.16	0.3331	24.6531
2400	2400	0.5247	4800.5247
2800	2800	0.6628	5600.6628
4800	4800	3.4286	9603.4286

Foundation: arrows of piles spaced as shown below under "Case 1."



CROSS SECTION OF MILWAUKEE CAISSON

Determination of Stress on Steel

$$\text{Case 1: } f = \frac{M_y}{I} = \frac{43,733,520 \times 121}{323,105} = 16,400 \text{ per sq in. at top.}$$

$$\text{Case 2: } f = \frac{M_y}{I} = \frac{98,400.339 \times 52.5}{323,105} = 16,000 \text{ per sq in. at bottom.}$$

SAMPLE COMPUTATION

STRESSES IN THE STEEL IN THE MILWAUKEE CAISSON

CONSIDERING THE WHOLE CAISSON AS A BEAM

SCALE 1" = 1'

W. J. Judson

Plate III.

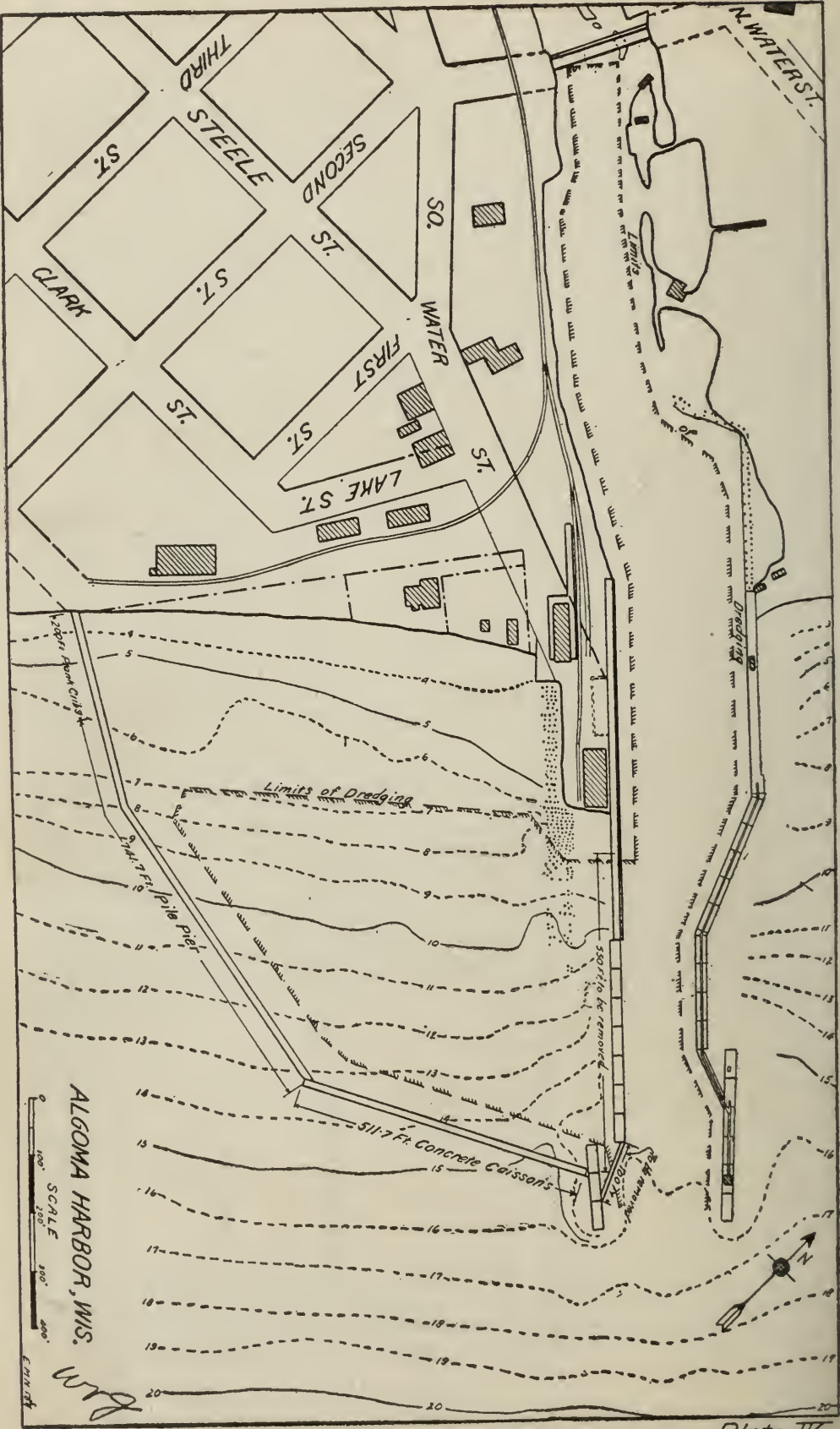
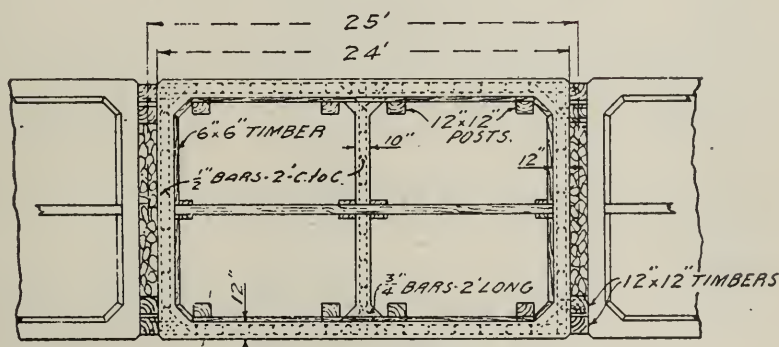
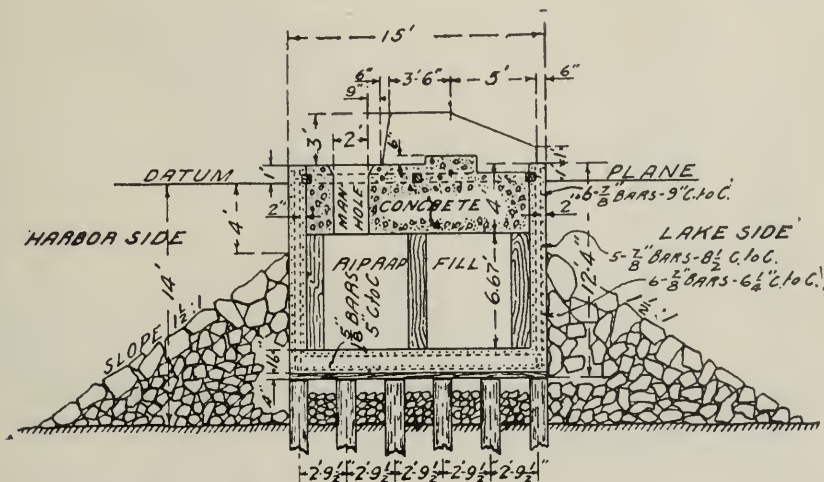


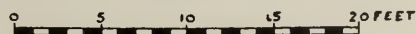
Plate IV.



REINFORCED CONCRETE CAISSON BREAKWATER
ALGOMA HARBOR, WIS.

ALGOMA HARBOR, WIS.

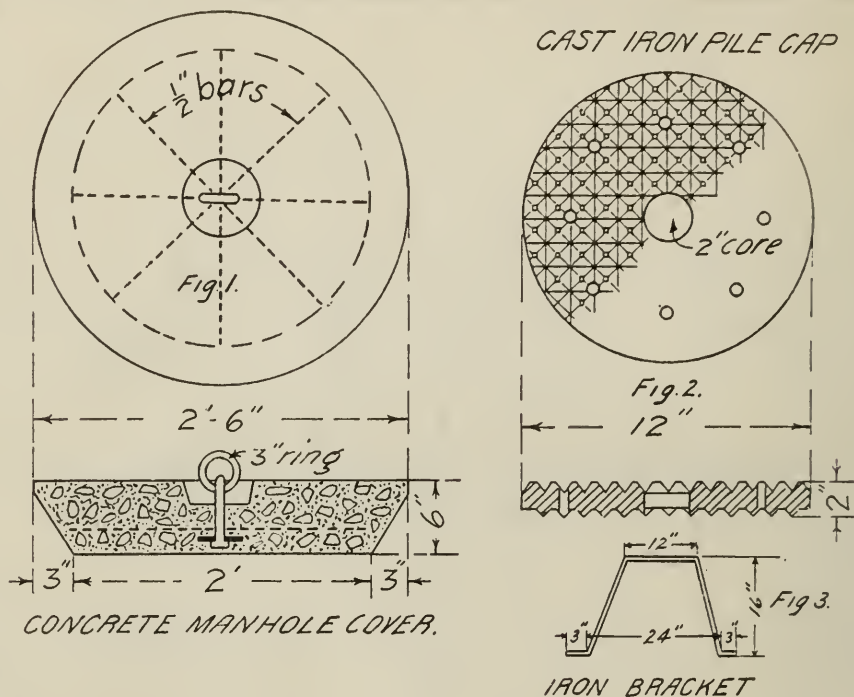
SCALE



Ben

S. P. 4

Plate V.

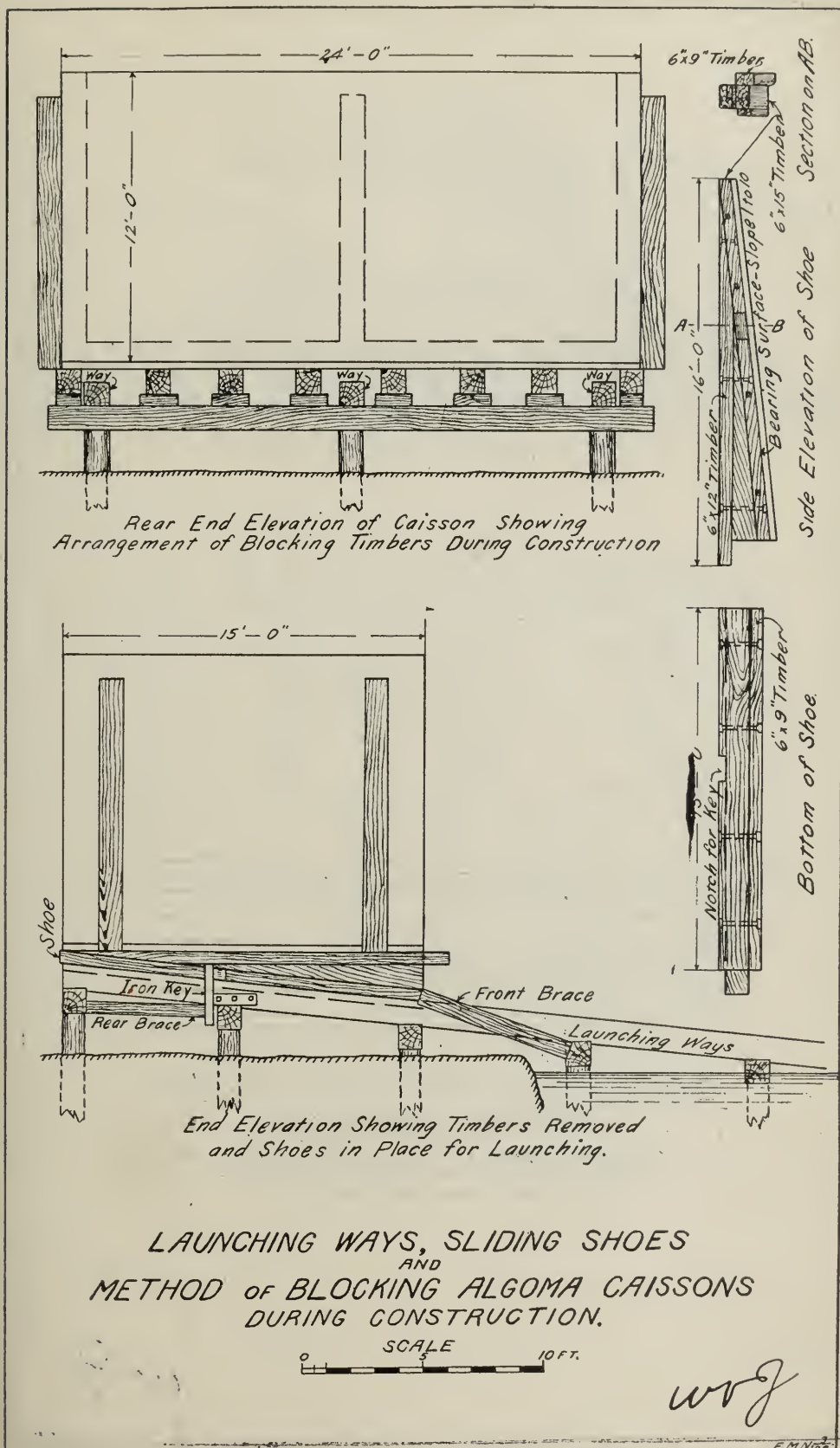


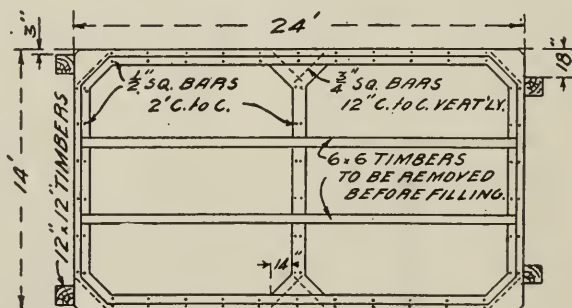
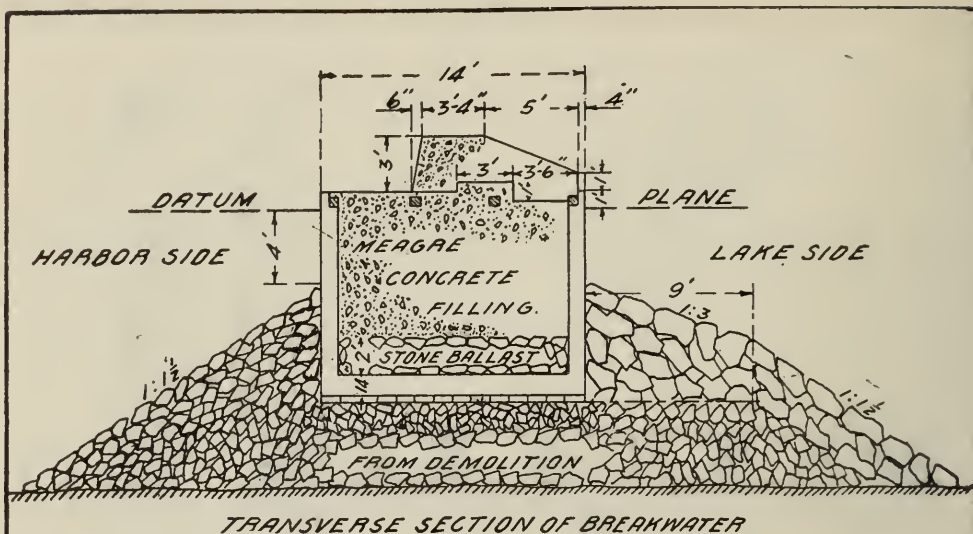
BILL OF MATERIALS		
CAISSON		
Reinforced concrete	per caisson	52.21 cu. yds.
Reinforcing bars	" "	13443 lbs.
Timber	" "	2252 ft. B.M.
Bolts and nails	" "	485 lbs.
FILLING		
Meagre concrete	per linear foot	1.61 cu. yds.
Timber	" " "	38.4 ft. B.M.
Riprap stone	" " "	3.32 tons
SUPERSTRUCTURE		
Concrete	per linear foot	0.79 cu. yds.
FOUNDATION		
Piles	per linear foot	28.8 lin. ft.
Riprap	" " "	9.03 tons
FILLING BETWEEN CAISSONS		
Riprap	per caisson	5.44 tons
Concrete	" "	0.53 cu. yds.

REINFORCED CONCRETE CAISSON BREAKWATER
ALGOMA HARBOR, WIS.

W. J. Judson

FIG. II





BILL OF MATERIALS-ONE CAISSON	
41.02 Cu.Yds. Concrete-	1-2-4 Mixture
97.3 Cu.Yds. "	Filling- 1-5-10 "
13425 Lbs. Reinforcing Bars	
2014 Ft. B.M. Timber	
470 Lbs. Bolts and Spikes	

REINFORCED CONCRETE CAISSON
ON STONE FOUNDATION
MANITOWOC HARBOR, WIS.

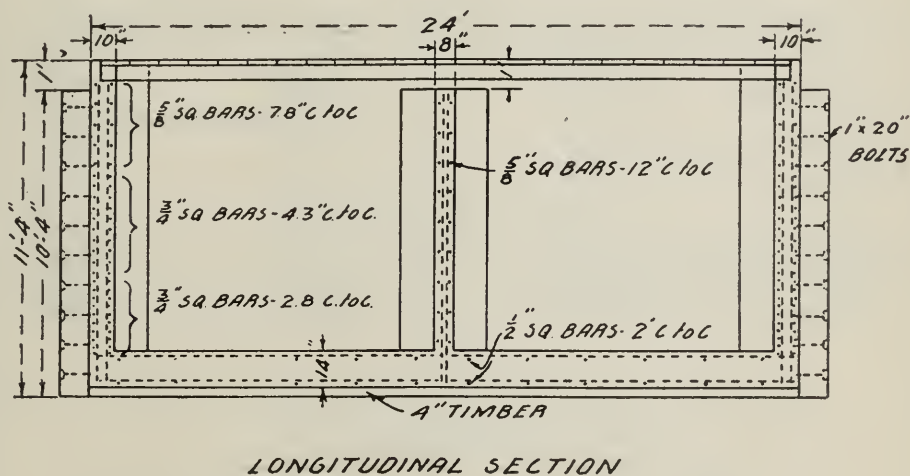
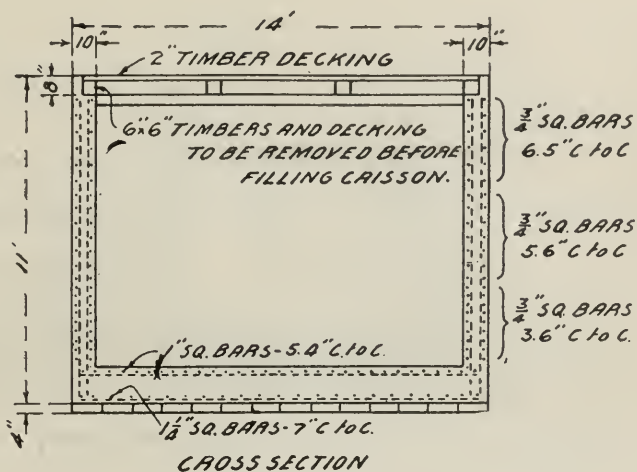
SCALE 0 14 FEET

wrg

S.K.A.

Plate VIII.

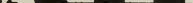
Vol. XIV. No. 4



REINFORCED CONCRETE CAISSON
ON STONE FOUNDATION
MANITOWOC HARBOR, WIS.

ON STONE FOUNDATION

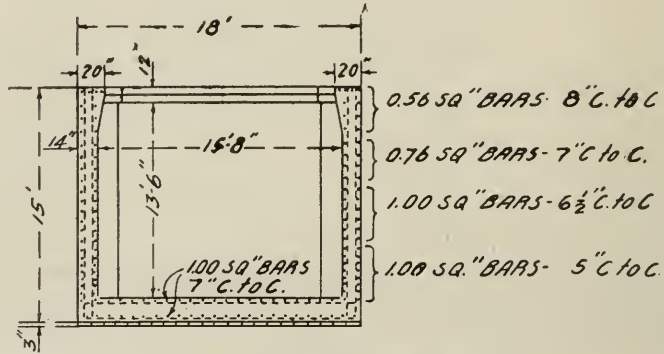
MANITOWOC HARBOR, WIS.

SCALE ⁰  ⁵ ¹⁰ FEET

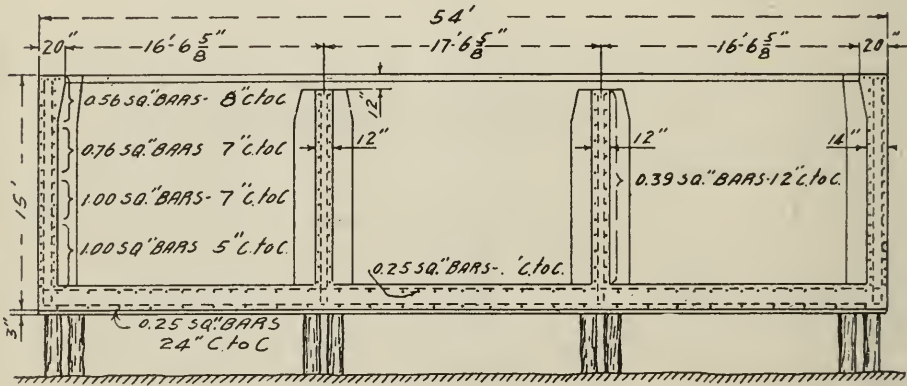
wrg

SRM

Plate IX.



CROSS SECTION SHOWING REINFORCEMENT



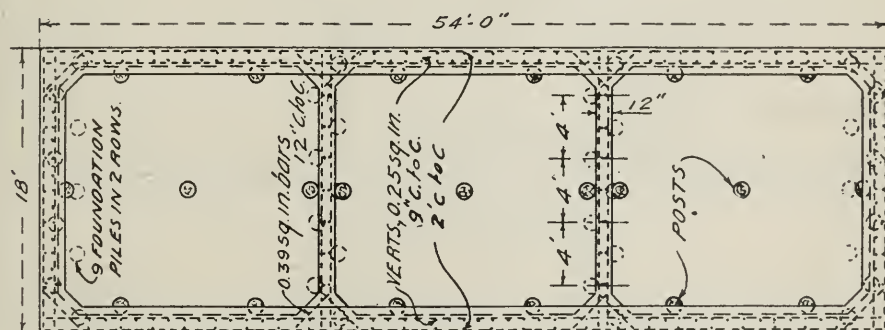
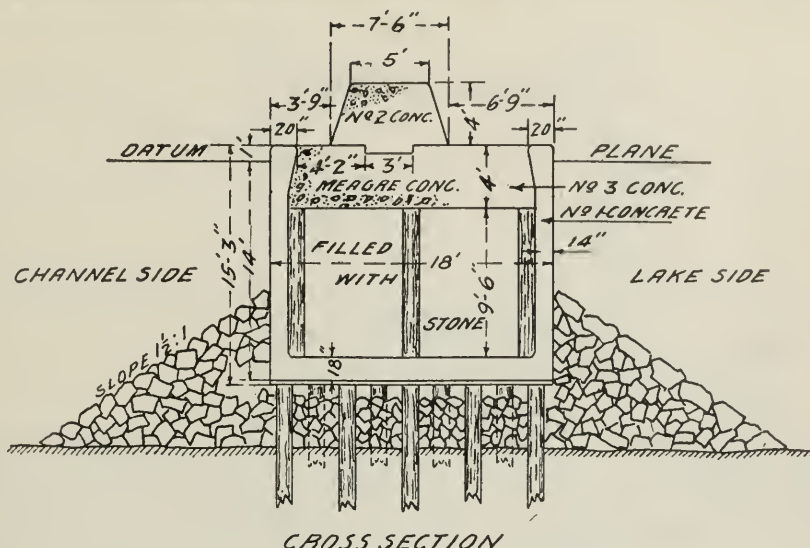
LONGITUDINAL SECTION SHOWING REINFORCEMENT

STEEL FOR REINFORCING					
122	BARS	1.00	SQ. IN. AREA	53'-6"	LONG
60	"	1.00	"	17'-6"	"
20	"	0.76	"	53'-6"	"
20	"	0.76	"	17'-6"	"
24	"	0.56	"	53'-6"	"
24	"	0.56	"	17'-6"	"
52	"	0.39	"	17'-6"	"
160	"	0.39	"	3'-0"	"
78	"	0.25	"	17'-6"	"
192	"	0.25	"	14'-10"	"
28	"	0.25	"	13'-10"	"

REINFORCED CONCRETE CAISSON
FOR SOUTH PIER
MILWAUKEE, WISCONSIN

SCALE 0 5 10 15 FEET

WJ



BILL OF MATERIALS		
CAISSON		
Reinforced Concrete	per Caisson	158.24 cu.yds.
Reinforcing Bars	" "	38553 lbs.
Timber	" "	2916 F.B.M.
Bolts and Nails	" "	580 lbs.
FILLING		
Meagre Concrete	per Caisson	109.6 cu.yds.
Riprap Stone	" "	344 tons
SUPERSTRUCTURE		
Concrete	per Caisson	52.81 cu.yds.
FOUNDATION		
40 Foot Piles	per Caisson	36
Riprap	" "	475 tons

REINFORCED CONCRETE CAISSON

FOR SOUTH PIER

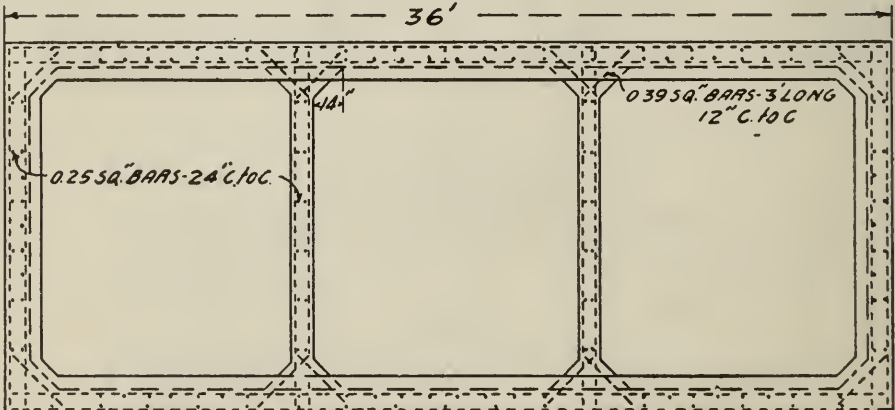
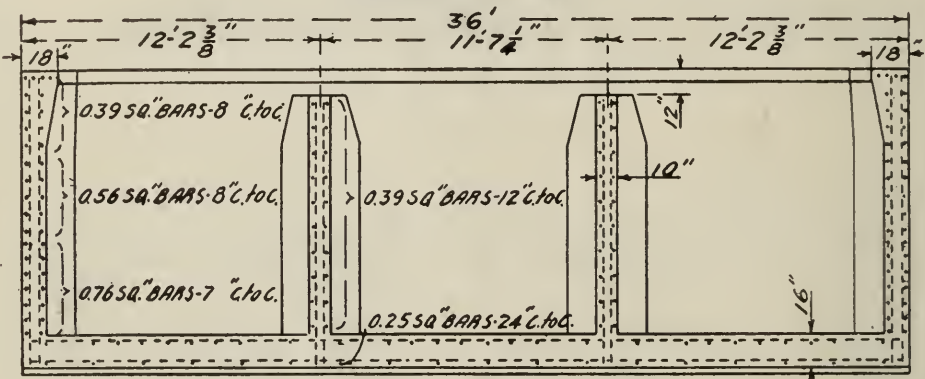
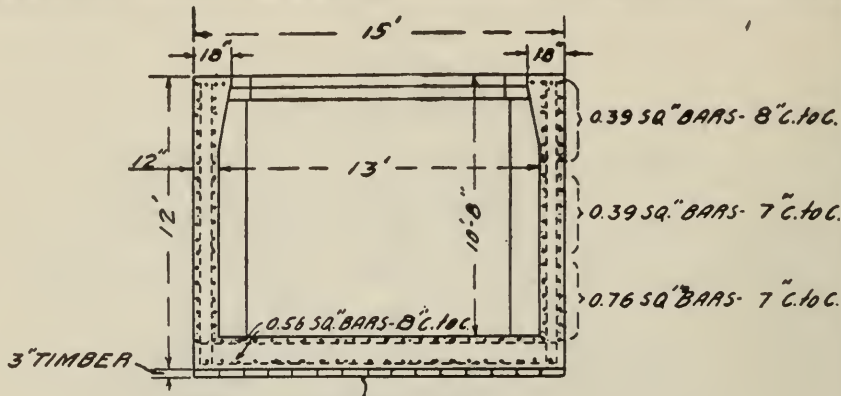
MILWAUKEE, WISCONSIN

SCALE 0 5 10 15 FEET

WRJ

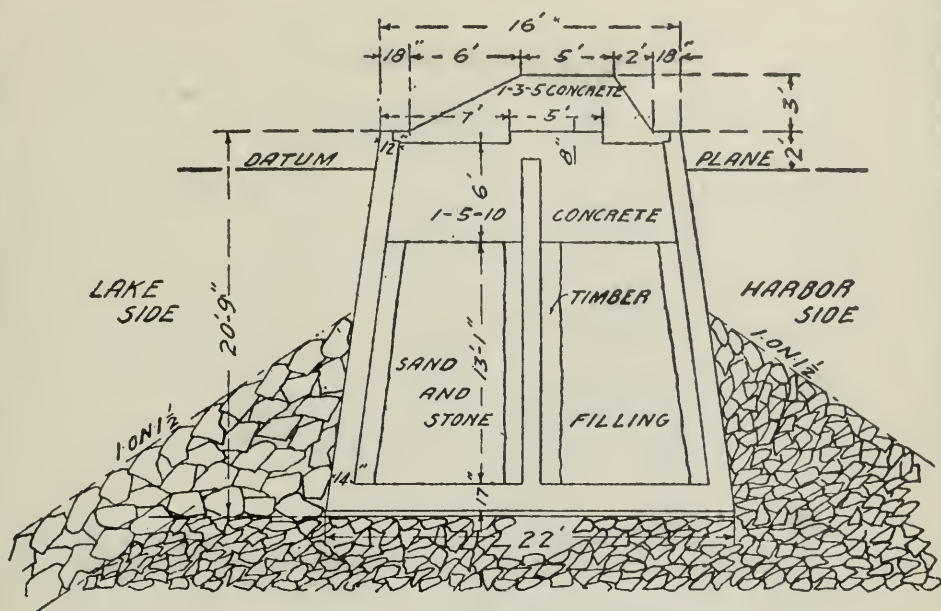
S.R.N.

Plate XI.

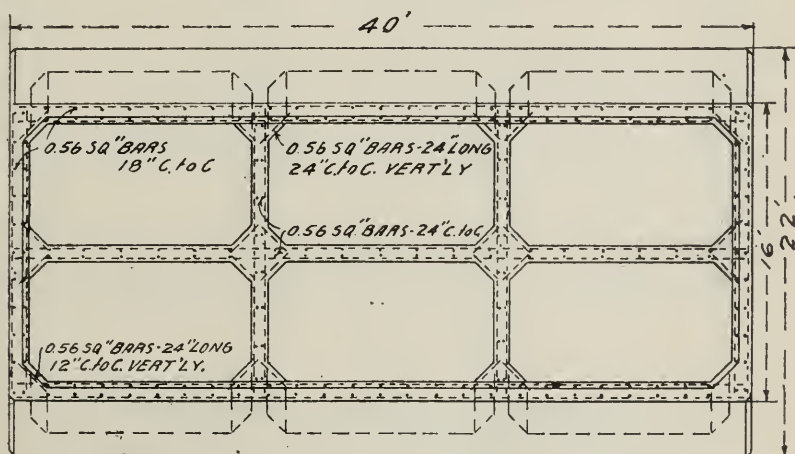


PLAN
REINFORCED CONCRETE CAISSON
FOR SOUTH PIER
MILWAUKEE WISCONSIN
SCALE 0 5 10 FEET

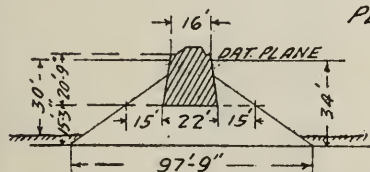
W.V.G.



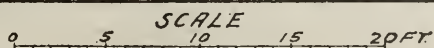
CROSS SECTION OF BREAKWATER



PLAN OF CAISSON



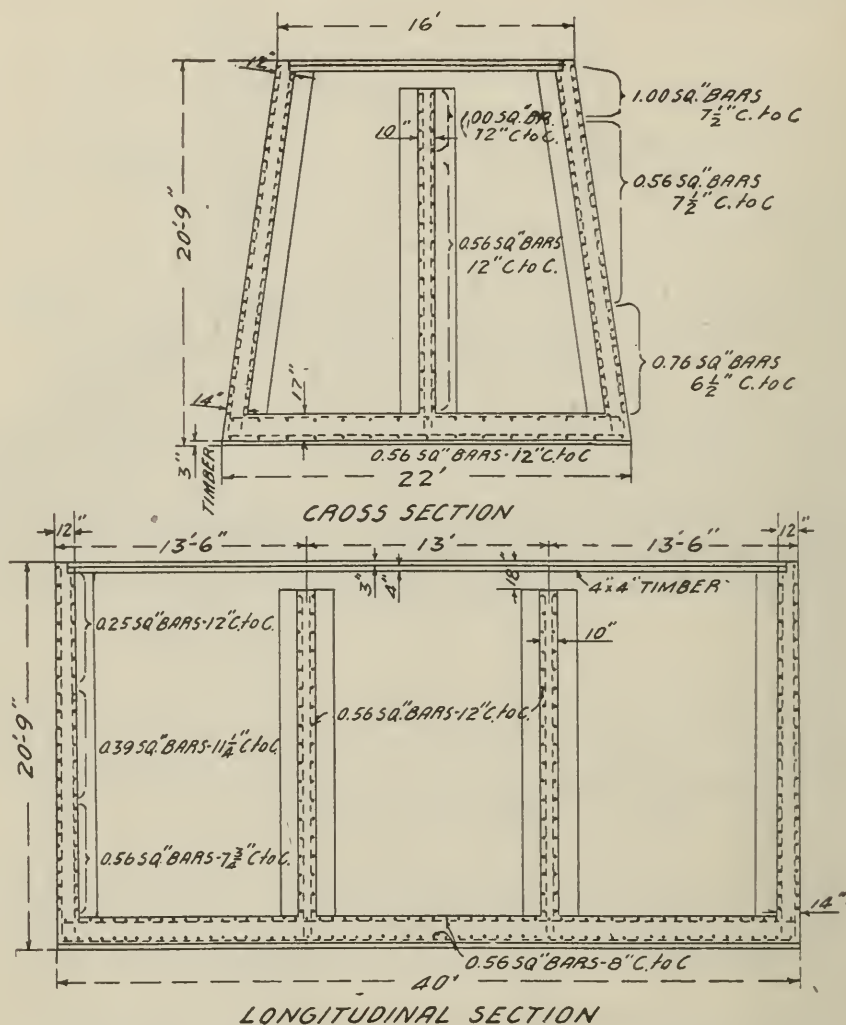
STUDY FOR BREAKWATER
IN THIRTYFOUR FEET OF WATER



W. J.

S. M. H.

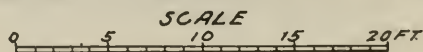
Plate XIII.



MATERIALS IN 40 FT. OF BREAKWATER

REINFORCED CONCRETE	179.41 Cu. Yds.
TIMBER IN FLOOR	2640 Ft. B.M.
SPIKES	280 Lbs
TAR PAPER	880 Sq. Ft.
STONE FILLING	373.2 TONS
SAND "	118 Cu. Yds.
POSTS	336 LIN. FT.
BURLAP	58 Yds.
CONCRETE FILLING, 1-5-10.	105.16 Cu. Yds.
CONCRETE IN SUPERSTR. 1-3-5-	48.91 " "
FOUNDATION, 15' BEAM	2509 TONS

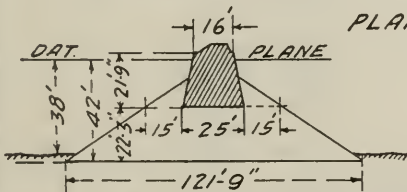
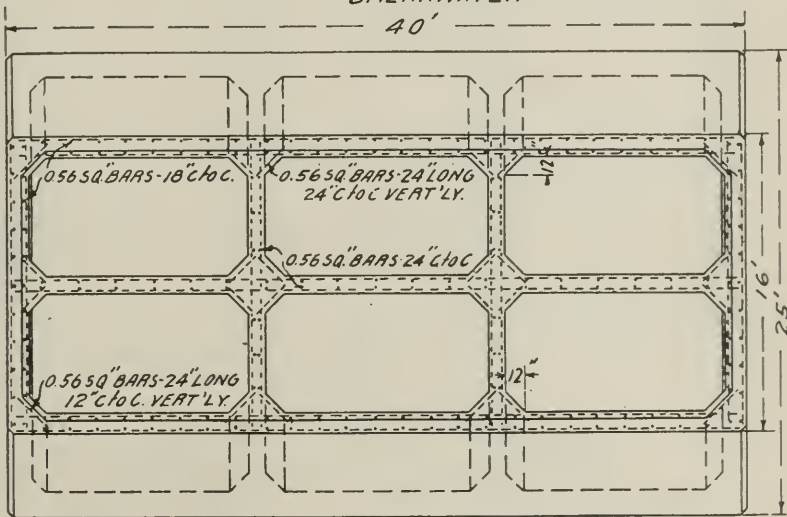
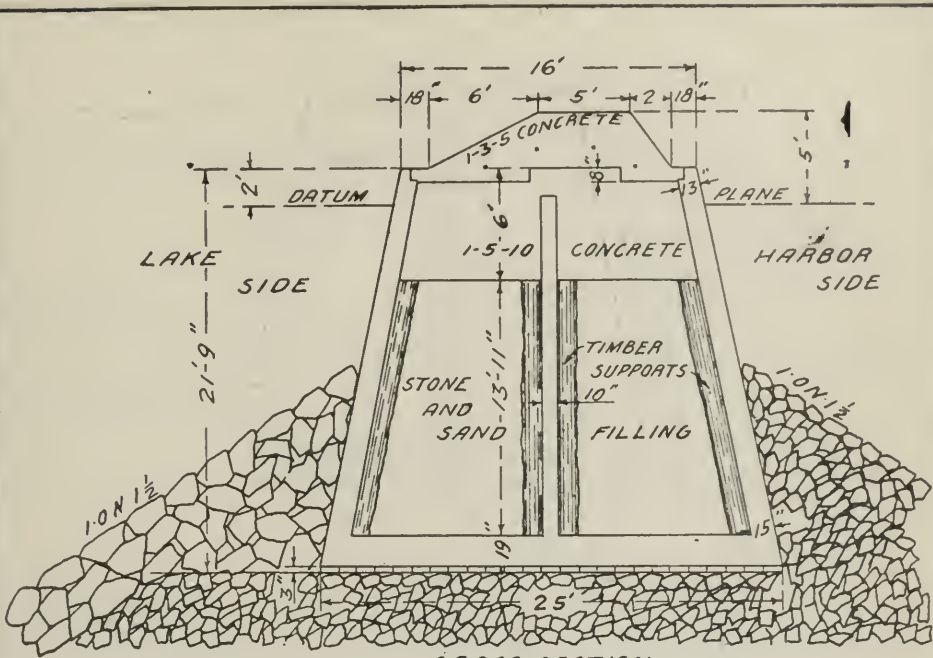
STUDY FOR BREAKWATER IN THIRTY FOUR FEET OF WATER



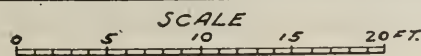
Woj

S.R.M.

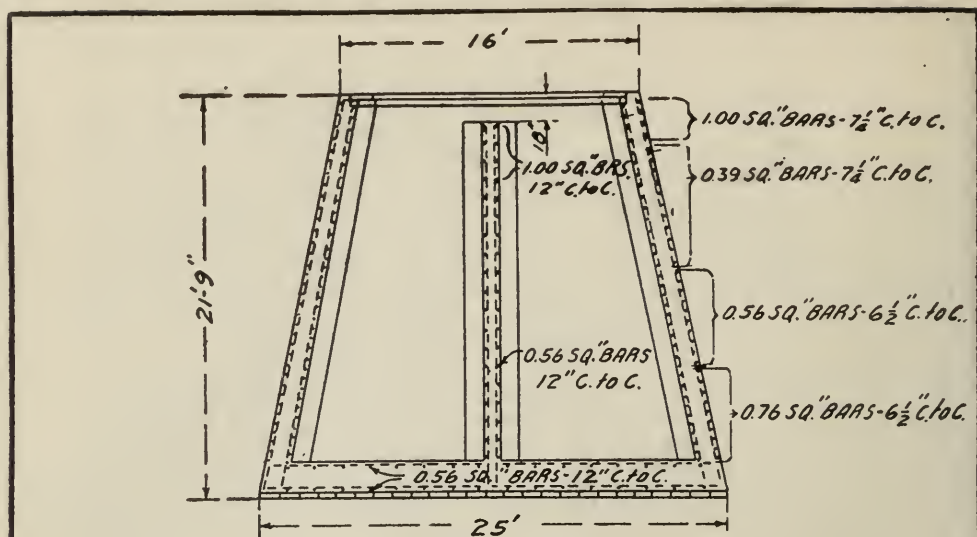
Plate XIV.



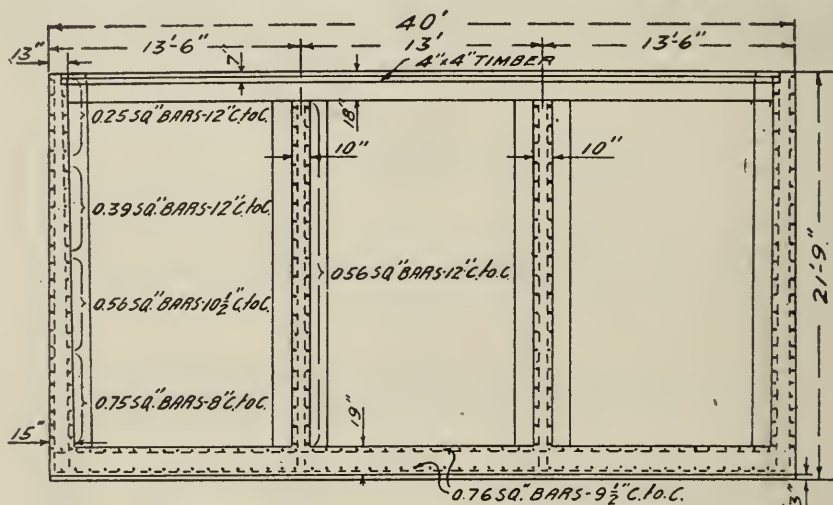
STUDY FOR BREAKWATER
IN FORTY TWO FEET OF WATER



wrg
SAH
Plate XL.



CROSS SECTION

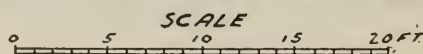


LONGITUDINAL SECTION

MATERIALS IN 40 FT. OF BREAKWATER

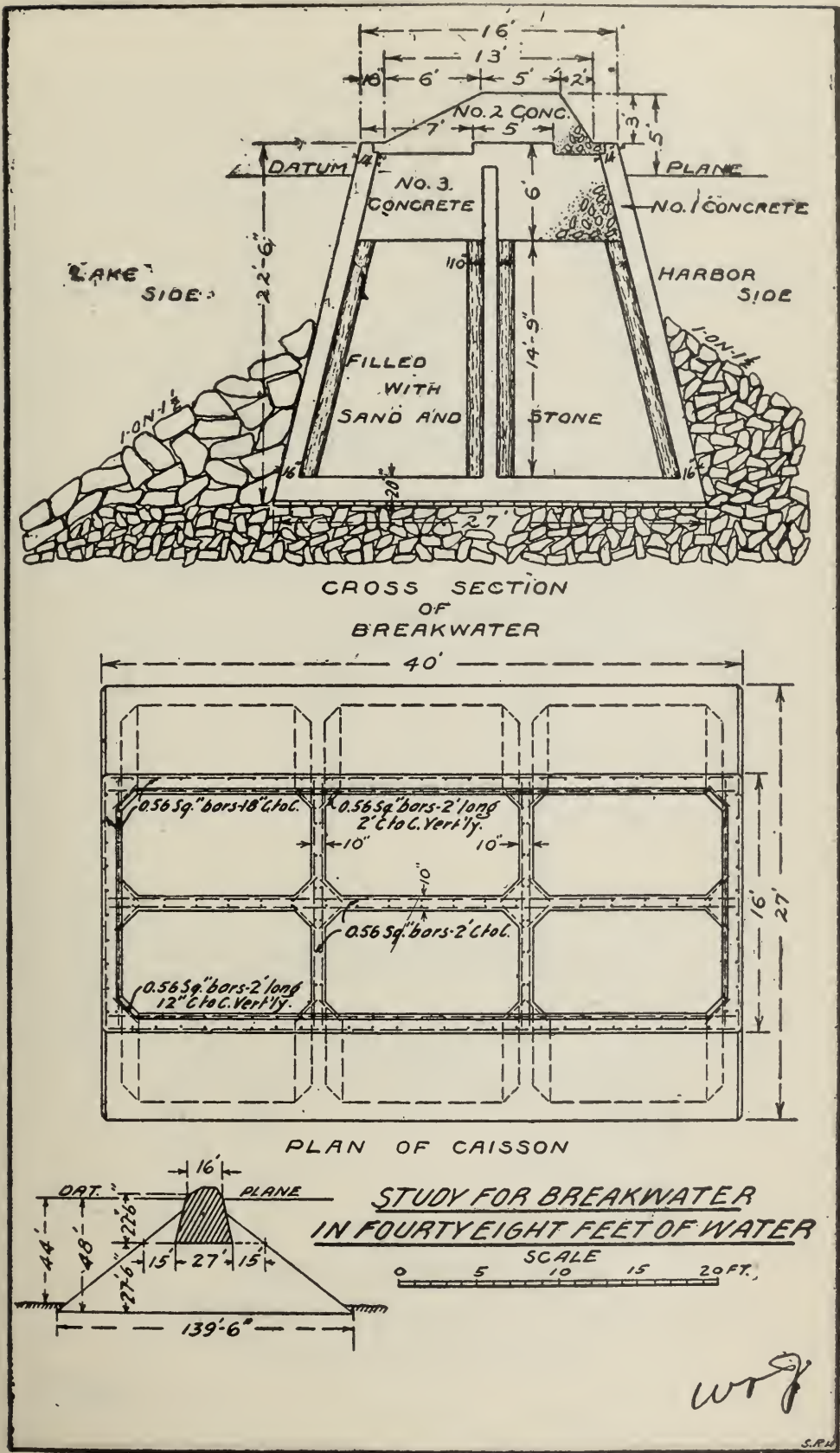
REINFORCED CONCRETE	207.22 Cu.Yds.
TIMBER IN FLOOR	3000 Ft. B.M.
SPICES	312 Lbs.
TAR PAPER	1000 Sq. Ft.
STONE FILLING	434.74 TONS.
SAND "	136 Cu. Yds.
POSTS	348 Lin. Ft.
BURLAP	60 Yds.
CONCRETE FILLING, 1-5-10	105.57 Cu. Yds.
CONCRETE IN SUPERSTR. 1-3-5	48. " "
FOUNDATION, 15' BEAM	41 TONS.

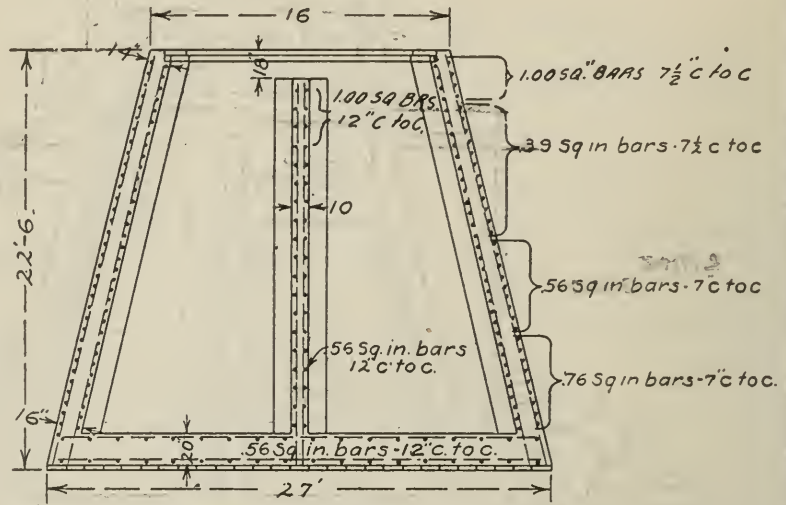
STUDY FOR BREAKWATER
IN FORTY TWO FEET OF WATER



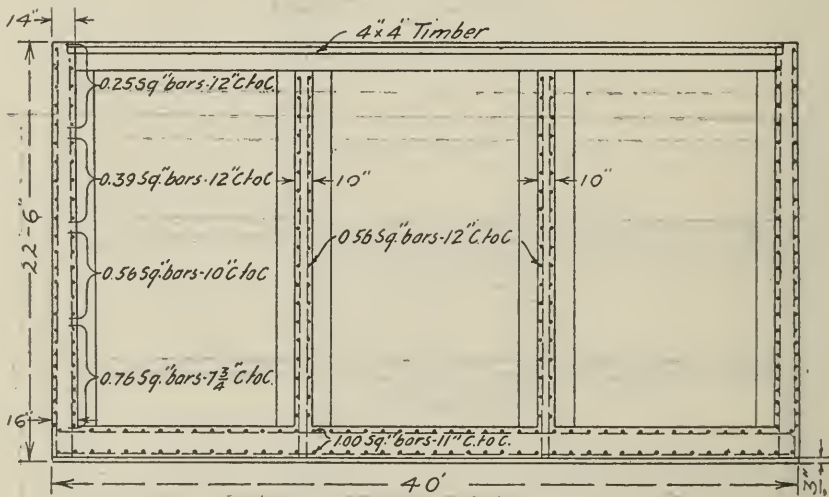
W.T.J.

Plate XVII.





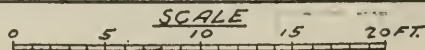
CROSS SECTION



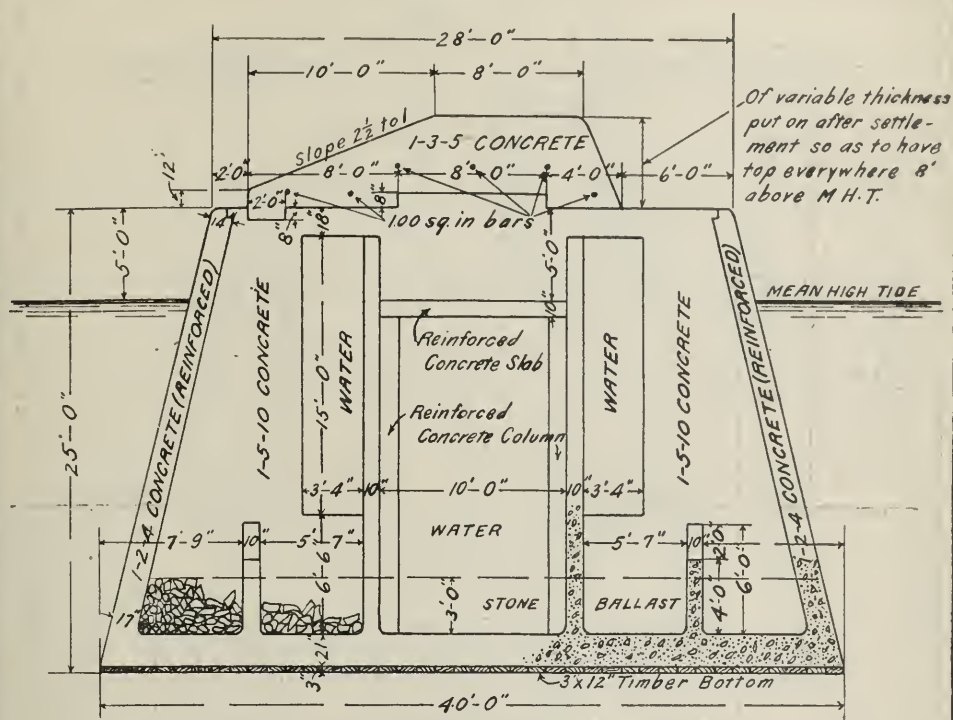
LONGITUDINAL SECTION

MATERIALS IN 40 FT OF BREAKWATER

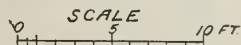
REINFORCED CONCRETE	230.76 Cu.Yds.
TIMBER IN FLOOR	3240 Ft. B.M.
SPIKES	336 Lbs.
TAR PAPER	1080 Sq. Ft.
STONE FILLING	478 TONS
SAND FILLING	150 Cu.Yds.
POSTS	372 Lin. Ft.
BURLAP	62 Yds.
CONCRETE FILLING - 1-5-10	105.8 Cu.Yds.
CONCRETE IN SUPERSTRUCTURE	48.91 Cu.Yds.
FOUNDATION STONE, 15' BERM	5528 TONS

STUDY FOR BREAKWATERIN FORTYEIGHT FEET OF WATER

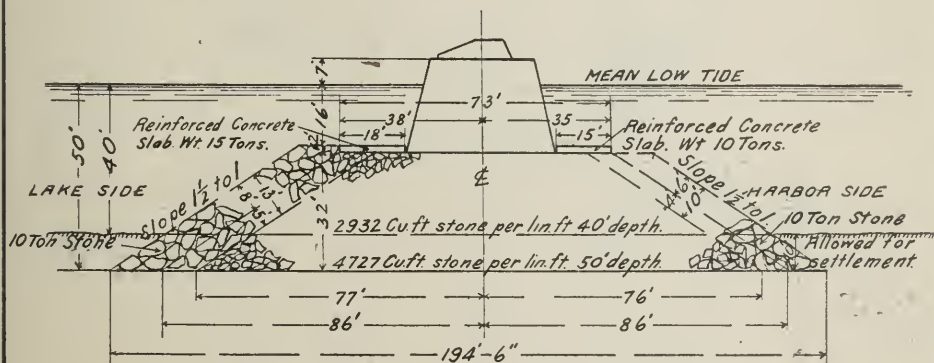
wjg



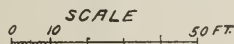
CROSS SECTION



CAISSON IS 42 FT. LONG HAVING 3 CROSS WALLS 10 IN THICK.
DRAFT OF CAISSON IN SALT WATER = 18.4 FT.



CROSS SECTION OF BREAKWATER

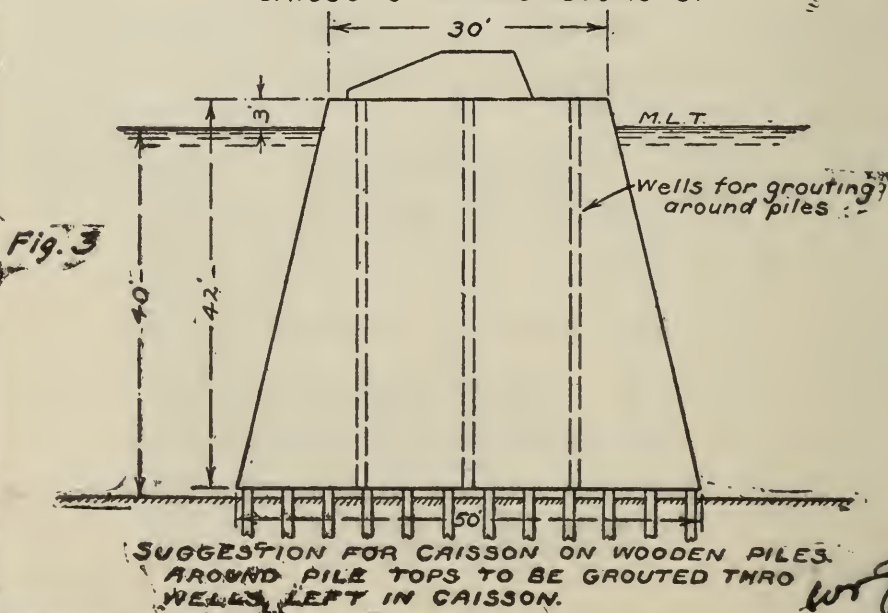
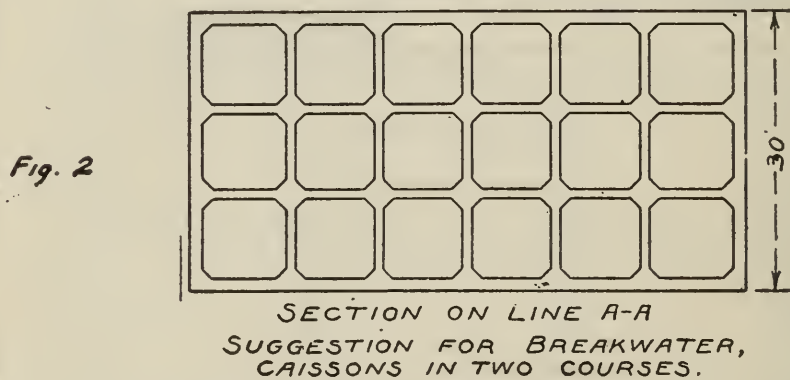
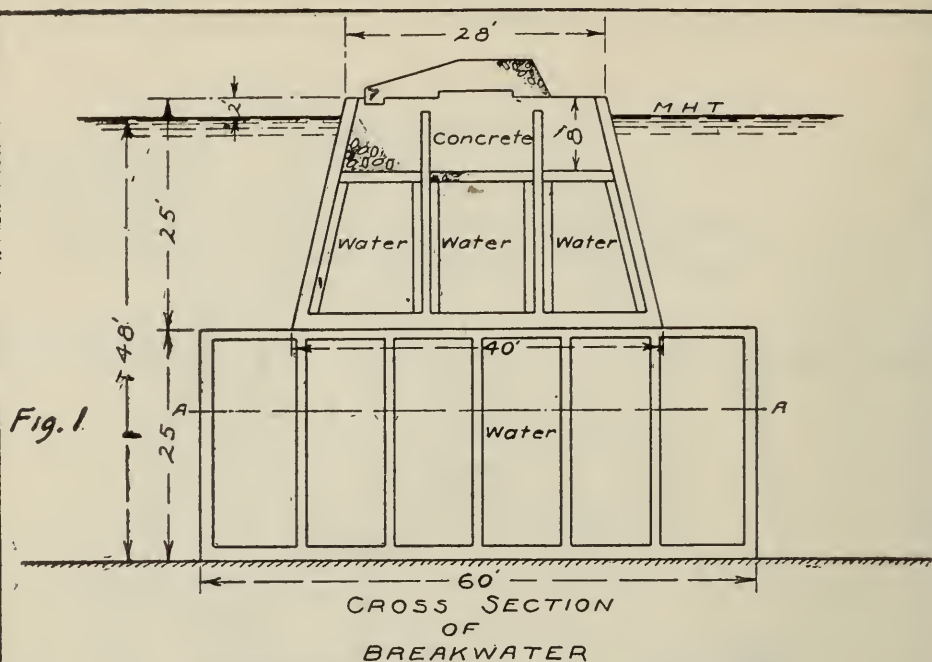


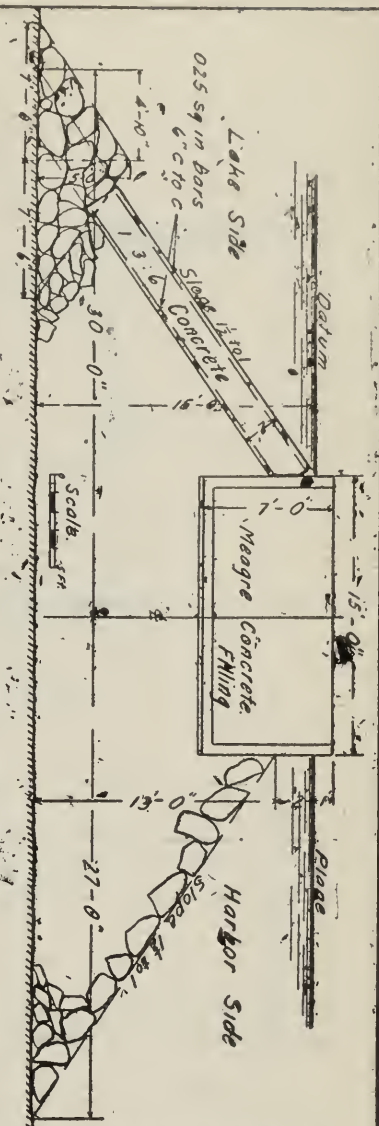
STUDY FOR BREAKWATER ENROCKMENT
WITH
CONCRETE-STEEL CAISSON SUPERSTRUCTURE
ON SOFT FOUNDATION IN EXPOSED LOCATION

SCALES: $\frac{3}{8}$ IN = 1 FT. & $\frac{1}{8}$ IN = 5 FT.

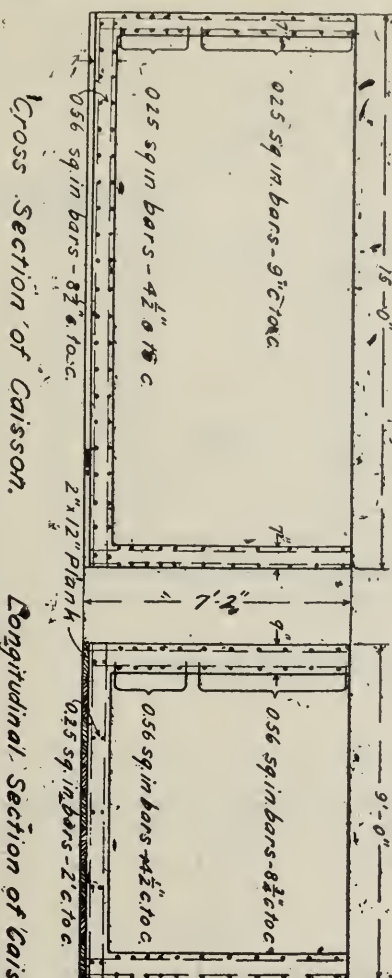
March 6, 1909.

wrg



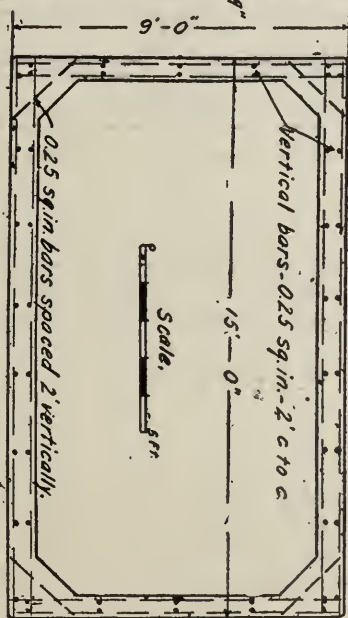


Cross Section of Breakwater.



Cross Section of Caisson.

Longitudinal Section of Caisson.

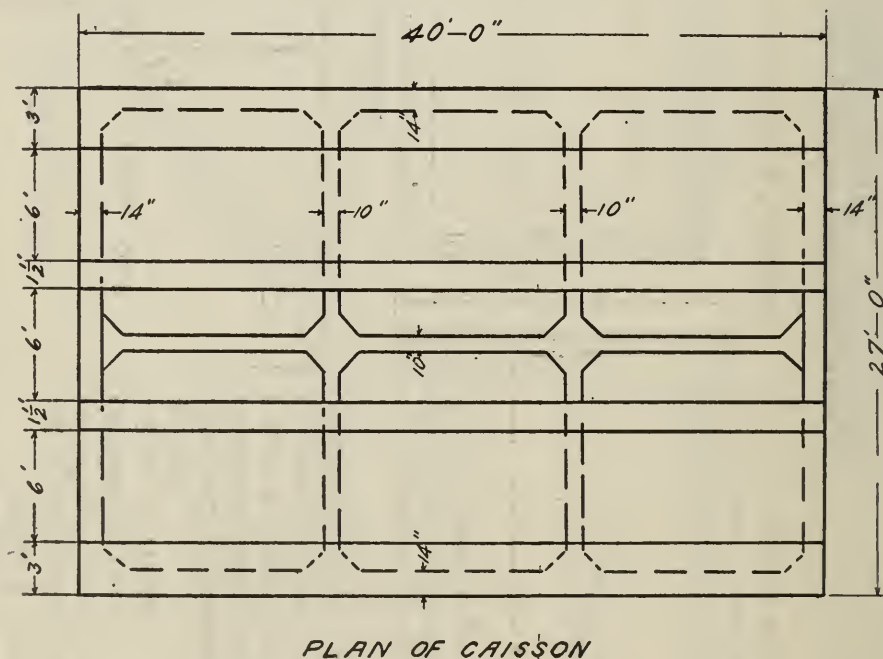
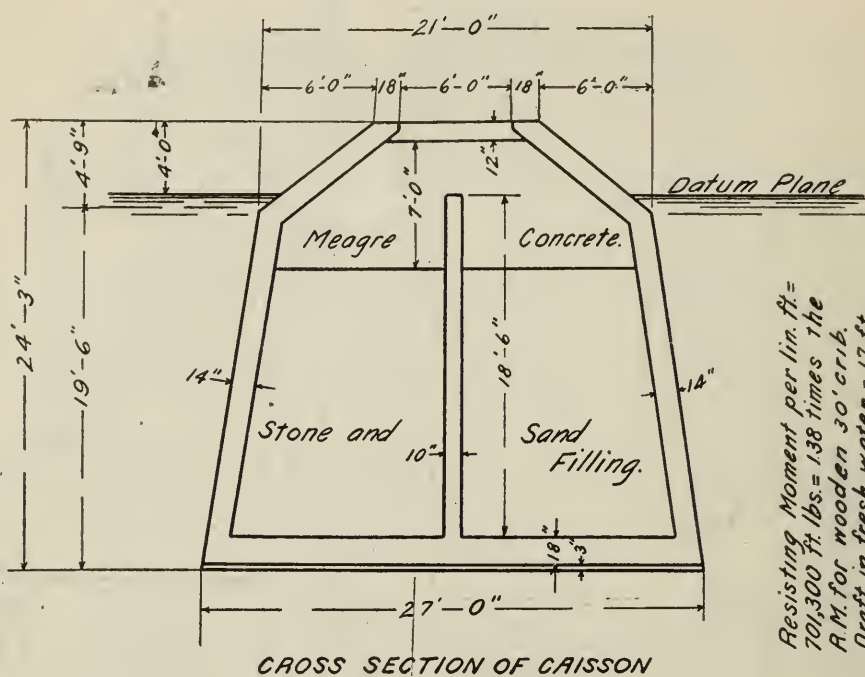


Plan of Caisson.

BILL OF MATERIALS.

Per caisson (9' long):	1
Reinforced concrete	108 cu yds
Reinforcing bars	2369 lbs.
Timber in floor	270 ft. b.m.
Spikes	36 lbs.
Per linft. of breakwater:	
Foundation stone and riprap	1944 tons.
Concrete filling 1-5-10	27 cu yds.
Concrete in slab 1-3-6	133 cu yds.
Reinforcing bars in slab	89 lbs.

**STUDY FOR ENROCKMENT BREAKWATER
CAPED WITH
REINFORCED CONCRETE CAISSON**

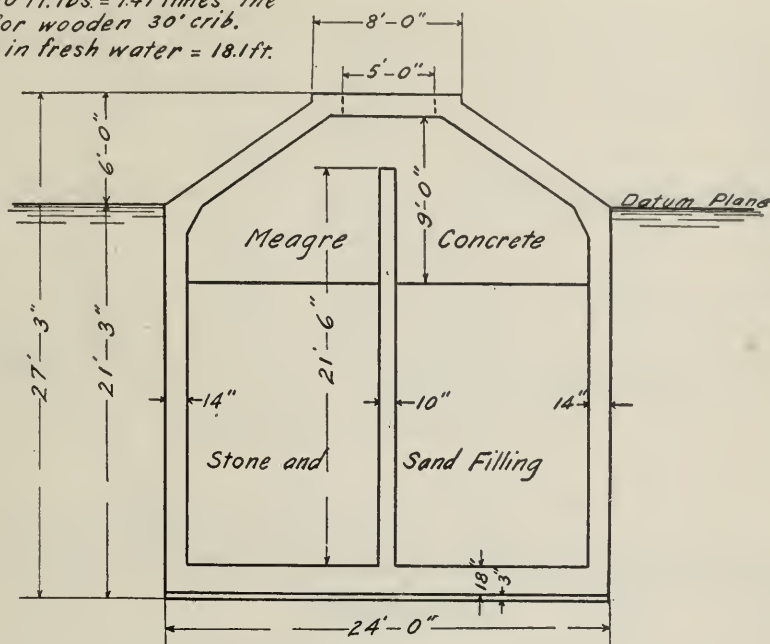


STUDY OF
CAISSON FOR BREAKWATER

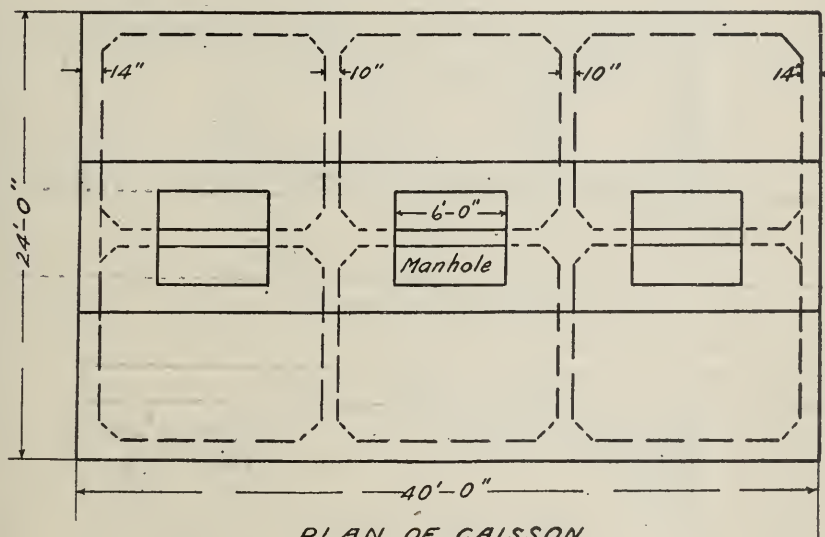
SCALE 10 FT

Plate XXII.

Resisting Moment per lin. ft. =
747,600 ft. lbs. = 1.47 times the
R.M. for wooden 30' crib.
Draft in fresh water = 18.1 ft.



CROSS SECTION OF CAISSON



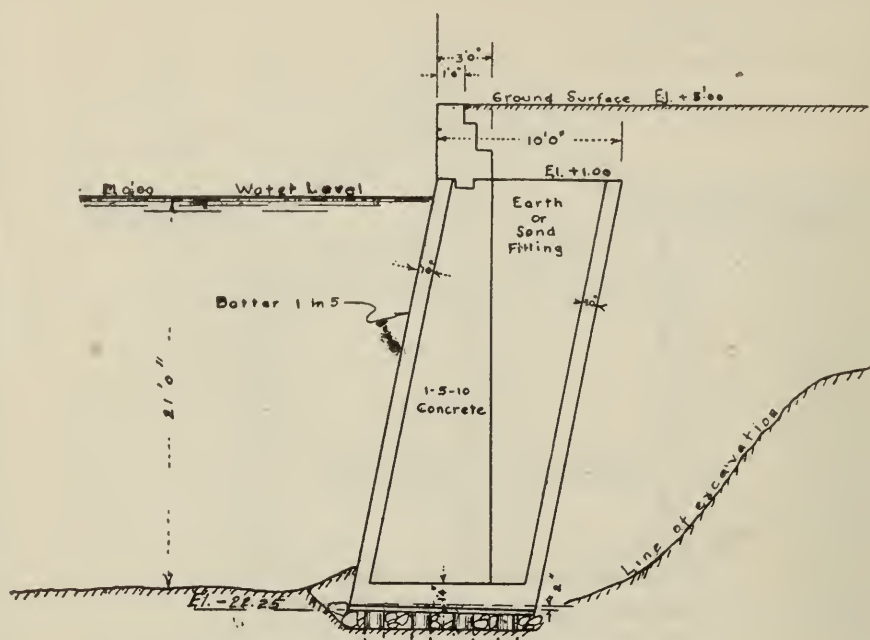
PLAN OF CAISSON

STUDY OF
CAISSON FOR BREAKWATER

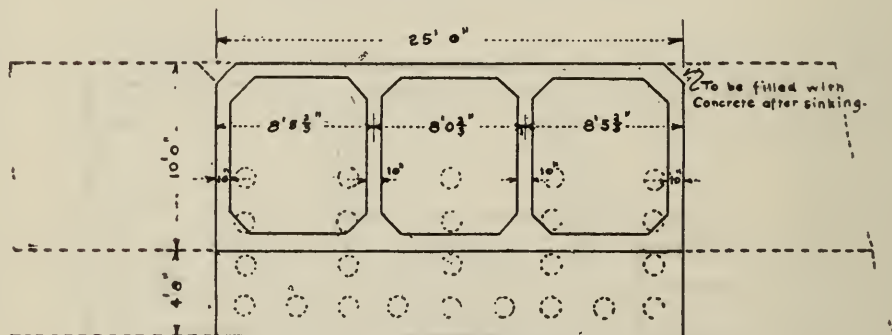
SCALE 10 FT.

Wry

Plate XXIII.



Cross-Section of Dock Wall



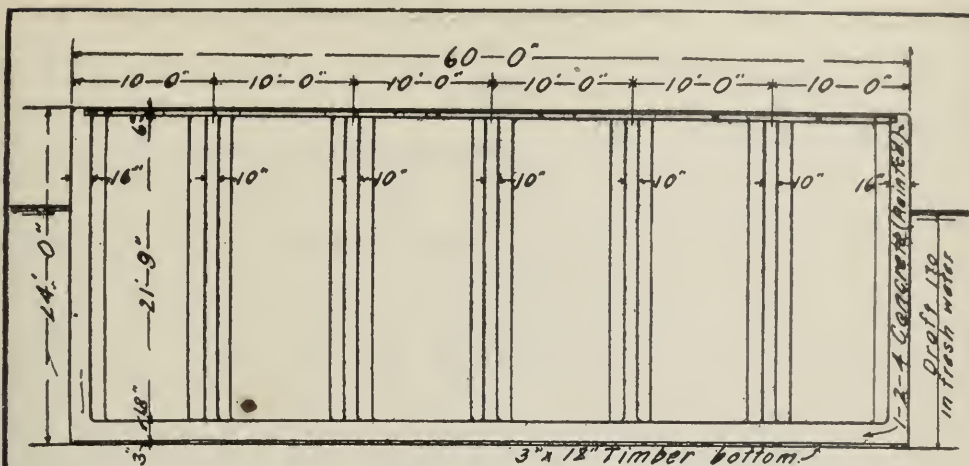
Plan of Caisson

Quantities		
Caisson - 25 ft long		
Reinforced Concrete	71.75	cu. yds.
Reinforcing Bars	12045	lbs
Timber	750	tr. B.M.
Spikes	66	lbs.
Concrete Filling per lineal foot	2.83	cu. yds
Earth or Sand	2.78	"
Foundation Piling	38.4	lin. ft
Foundation Riprap	0.82	tens
Concrete in Parapet Wall, per lineal foot.	0.35	cu. yds

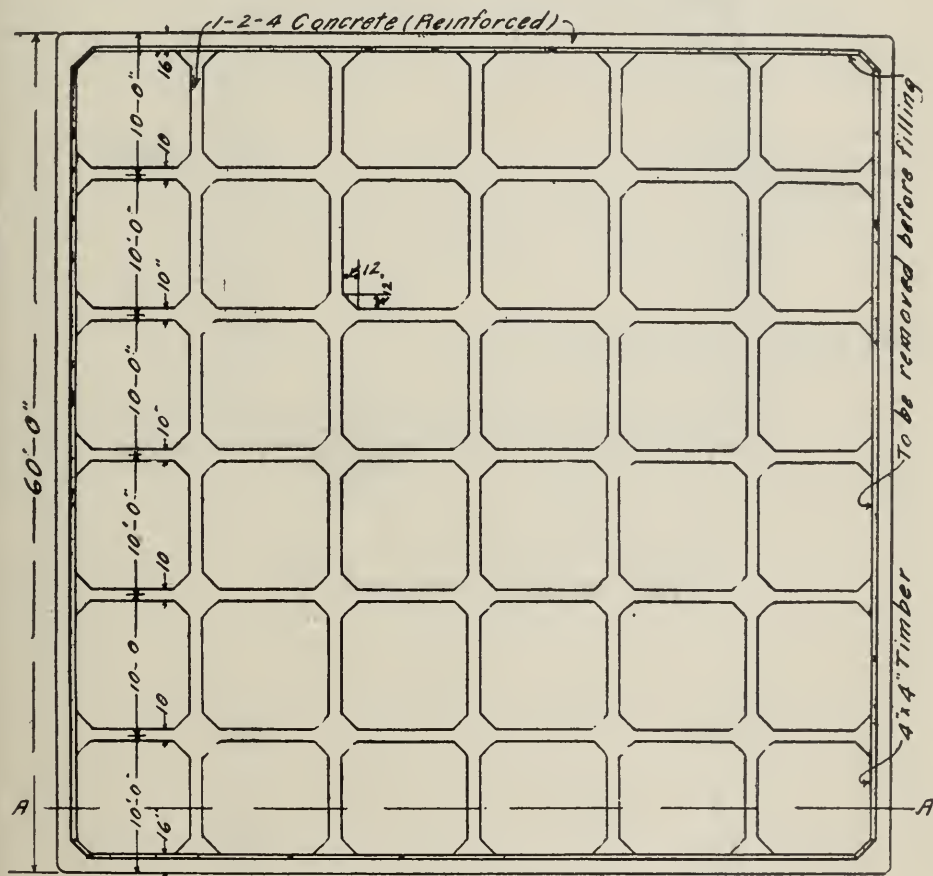
Concrete Caisson Dock Wall



wrg



CROSS SECTION A--A.



PLAN OF CAISSON.

CONCRETE-STEEL CAISSON
FOR
LIGHT HOUSE FOUNDATION.

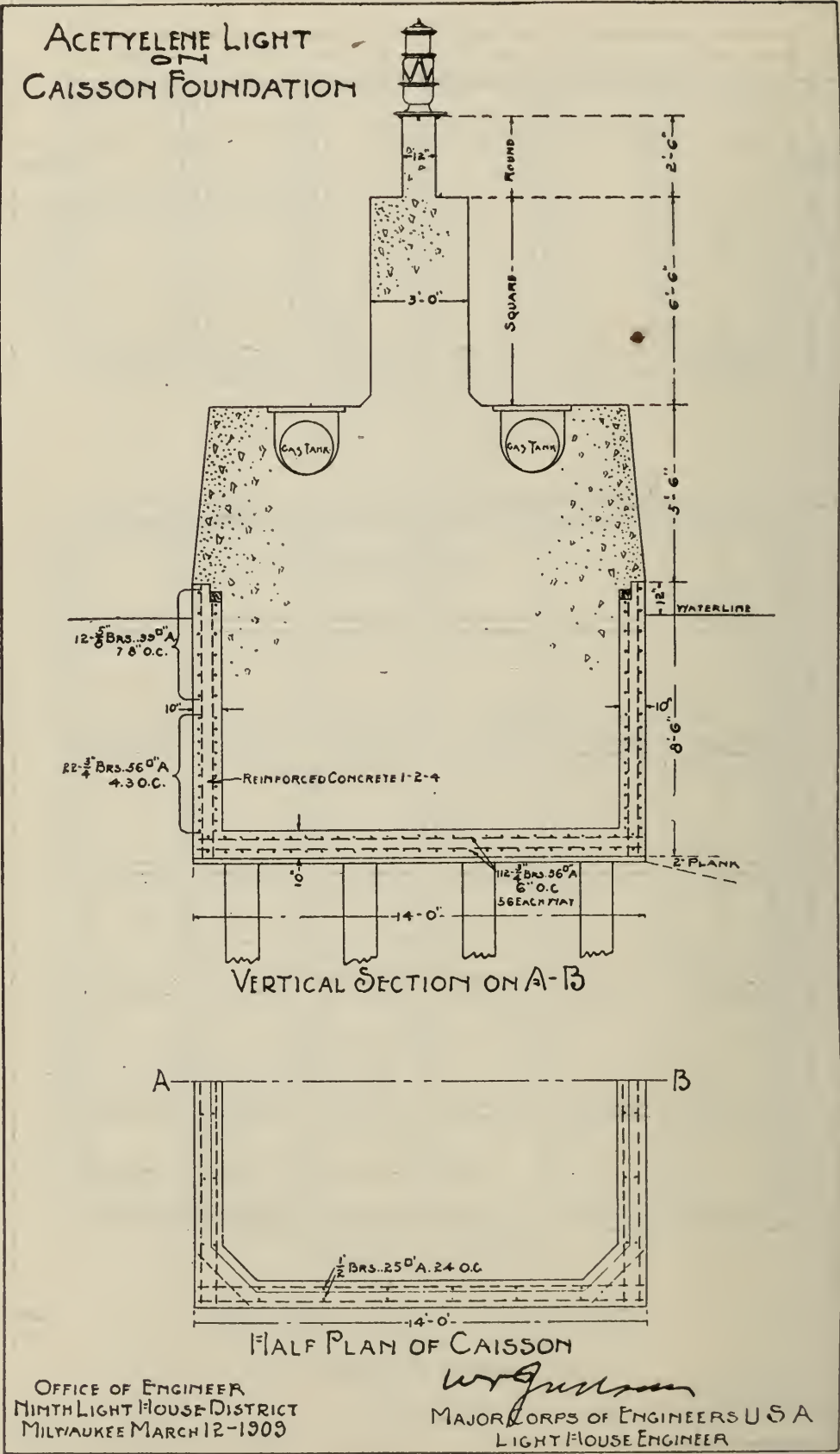
Feb'y 25, '09

W. J. Judson

SCALE OF FEET

E.M.

Plate XXV



DISCUSSION.

Mr. W. H. Finley, M.W.S.E.: Referring to the design for the concrete dock front; the caisson is floated out, as I understand it, and the concrete is backed up against it in front inside of the caisson. I judge you would have to be careful in putting that in, so that in receiving blows from boats there would be no separation of the backing? Have you given that any consideration?

Maj. Judson: The caisson shown on Plate XXIV. has three chambers. Two would be filled with water to hold the caisson down, a vertical form would then be lowered in the third chamber and the concrete put in in the dry. After the concrete is in, the space behind it is filled with sand or some other material, and the backing is placed behind the caisson. I do not think there would be any opportunity for damage such as you mention. If the caisson were filled merely with sand, it probably would not be punctured frequently, but with this weight of concrete and other materials behind it I think it will certainly hold up. The cost per lineal foot would be increased but slightly if these dock-front caissons were entirely filled with concrete.

Mr. Finley: What is the difference in cost between this form of construction and wooden crib construction?

Maj. Judson: You will find many comparative estimates of cost in the body of my paper, which I have omitted reading tonight for lack of time.

Mr. L. K. Sherman, M.W.S.E.: Referring to the cost of timber crib foundation, the Sanitary District built about 1,000 feet of this in Lake Michigan, near Wilmette, 16 ft. wide and 15 ft. high. The average cost was \$39.00 per lineal foot. The cost per cubic yard of structure was \$4.50. That did not include any pile foundation.

Maj. Judson: In the case of the Algoma work, the water was 15 ft. deep instead of 11 ft., and the width in such a depth, instead of being 16 ft., would be some 22 ft. if built of wood, and with a factor of safety against overturning equal to that possessed by the concrete caissons. If you apply your cost per cubic yard, \$4.50, to a structure of wood 22 ft. wide in 15 ft. of water you would have a cost of \$69.66 per lineal foot, not including the rock placed on the beams, nor pile foundation. If the cost of the pile foundation and of the rip-rap placed alongside the caissons be subtracted from the cost of the Algoma work, we have left a cost of less than \$60.00 per lineal ft., and the \$60.00 work is permanent while the \$69.66 work is not. Thus your Wilmette work, with the cost data derived therefrom, when compared properly with the Algoma work, demonstrates the greater cheapness of the latter. As I understand, your Wilmette work, the tops of the wooden cribs projected 4 ft. above the water. This part will of course be subject to decay, and will require constant maintenance.

Mr. Sherman: This \$4.50 spoken of would apply only to the neat

section of the structure, and would not include rock filling on the outside or anything of that sort.

Maj. T. H. Rees, M.W.S.E.: With reference to the building of a superstructure of concrete on a timber crib foundation, there has been some experience with the north pier in Chicago, at the Chicago River. It was supposed that by cutting down the timber work to two feet below datum, the timber would be found perfectly sound, but when the work was begun it was found necessary to go down at least eight feet before a solid foundation could be obtained for the concrete block, which made the work expensive. It appeared to me, while listening to the paper, that the floating dock might be very well adapted to the construction of those caissons, especially in cases where they had to be built in a harbor in which the depth of water was not sufficient to float the caisson. With a floating dock, it could be built alongside the wharves and be moved under the concrete plant at another wharf and receive its concrete, and when finished it would still, on a floating dock, have less draught than when it is launched and floated by itself. Then it could be floated out into deep water and put into its place.

I am not one of those who believe we should use only the cheapest form of construction for all purposes. I think it is worth a good deal to build something that will last and will have a good appearance for a long time. If any of you will look at some of the piers and breakwaters that are still here, with the wooden superstructures, they will be found in all stages of decay and delapidation, and do not present the pleasing appearance, of the first year or two after their construction. I would like to see them built of concrete.

A. Ross, Rear Admiral U. S. Navy: Referring to the matter of quay-walls of your harbors, I would ask whether you would use any protection piles in the front and chafing blocks?

Maj. Judson: Yes, one or both.

Admiral Ross: Have you made any arrangement for brackets?

Maj. Judson: Not in connection with caisson illustrated this evening, but obviously such arrangements could easily be made.

Admiral Ross: I think many of the gentlemen present would be interested in the Naval Training Station now being constructed at North Chicago. We have had more problems to thresh out there than in any other station.

We have there a harbor 400 ft. by 800 ft., and this question comes in nicely, because the whole of that harbor must have a quay-wall around it for the hoisting out of boats of all kinds. The boats are hoisted every night, but during the winter they are run into a boat-house that we built on the edge of this harbor. From the entrance to the harbor it is about 650 ft.

We cannot afford to use the method of concrete caissons described by Maj. Judson. We are putting in a crib similar to the one Maj. Judson has shown us. It is a very good crib and a very economical one. That is carried out 650 ft. On the end of that is another crib

placed at an angle of 45 degrees, narrowing the entrance of the harbor to 150 ft. The distance between piers is 400 ft. This system of concrete caissons would be the ideal one.

This plan for reinforced concrete caissons fills a want that is growing every day, on account of the timber question that is coming up in this country. They have gone so far abroad as to build boats out of reinforced concrete, and they stand the wear and tear very well; they stand, not only the shocks of the sea but of vessels coming alongside.

Col. C. McD. Townsend, M.W.S.E.: While believing that the days of the timber crib are numbered, I have to invite attention to the fact that it has been one of the most useful of the engineering instruments employed in developing our harbors. Without it, it is improbable the commerce of the Great Lakes would have attained its present magnitude. When the first works of harbor improvement were undertaken, Chicago, Cleveland, Buffalo and Duluth were insignificant villages as compared to their present dimensions, and if the Engineer had even suggested a breakwater costing \$200 per running foot, it is questionable if a large proportion of the harbors along the lakes would have been started. Economical construction was a very essential item in their development, and the timber crib in early days was a structure so cheaply built as to excite the wonder of European Engineers.

We are hearing a great deal about the conservation of our resources, and from the statement made it would appear to be a general opinion that the farmer who has cleared his land, and the engineer who has lavishly employed timber in construction, are in some way guilty of a crime against the commonwealth. I have to suggest that our wonderful commercial development has been due to this prodigal and even wasteful expenditure of our natural resources. We have probably now arrived at a period in our history when it is advisable to economize in these expenditures, but if so, the declamation of the politicians will be of little avail. The conservor of our resources has and always will be the Engineer who like Major Judson, when the price of an article becomes excessive suggests a substitute.

The necessity of obtaining a substitute for the timber crib has resulted not only from the increase in cost of timber, but also from the necessity to give greater strength to the structure as the depths of our waterways have increased.

In the first pier construction extensive use was made of slabs, the refuse of saw mills, or of a pile structure filled with stone, but as the piers were extended into deeper water, timber cribs became necessary, which has gradually been strengthened until they reach their final development in the Cleveland breakwater, as described in a paper by Colonel D. C. Kingman published by the American Society of Civil Engineers in 1904. In this breakwater the cribs are given sufficient strength to support a concrete superstructure, anticipating the abandonment of timber construction above water. Major Judson

now eliminates all timber but a platform, by making the substructure of reinforced concrete.

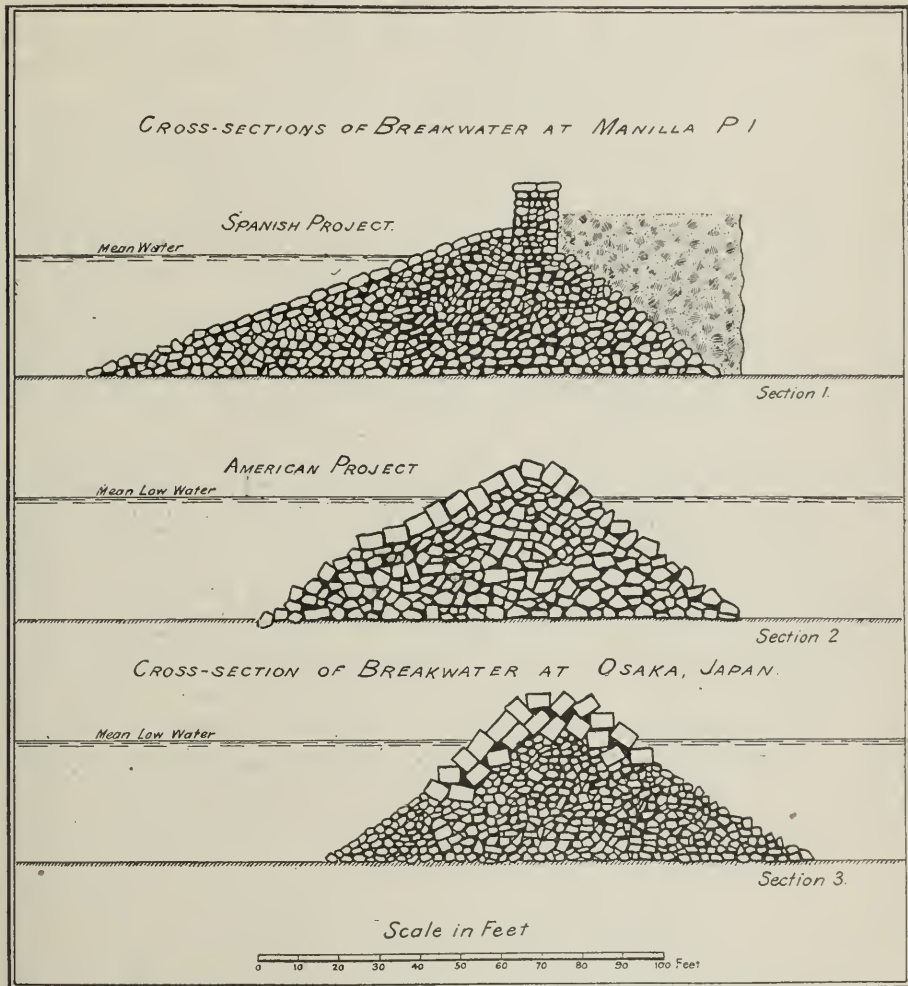
About twelve years ago, when in charge of the harbors on the eastern shore of Lake Michigan, I noted the rapid increase in the cost of the timber crib, and suggested that the rubble mound would ultimately be a cheaper structure where rock could readily be obtained. Authority was granted to make the experiment, and at Petoskey and Clarlevoix we built short sections of rubble mound breakwaters to replace timber cribs. The cores of the breakwaters were composed of shale and small stone covered with granite boulders from along the lake shore. A novelty in their construction was that they were built in the winter by cutting a hole through the ice through which the material was deposited. The first cost of these breakwaters was less than if built of timber cribs, and though of much weaker design than I would now recommend; their cost of maintenance has been less than that of the neighboring timber structures.

The rubble mound breakwater has since then been constructed at numerous localities in the improvement of the harbors of Lake Erie, and it is with this type of breakwater, not the timber crib, that the reinforced concrete caisson will have to compete. This revives a discussion which has agitated European Engineers for the past 50 years, as to the relative advantages of the rubble mound and vertical faced types of breakwater, and which is ably summarized by Sir Vernon Harcourt in his work on Harbors and Docks.

The caisson of reinforced concrete will enable a vertical faced breakwater to be built more cheaply than those of mass concrete such as have heretofore been constructed in Europe, but American practice has also led to great economies in rubble mound construction. The rubble breakwaters of Europe were originally constructed of comparatively small stone, as at Portsmouth and Cherbourg, and when exposed to wave action very gentle slopes were formed, so that an enormous mass of material was required to form the mound. More recent practice, as illustrated by the breakwaters at Port Said and Alexandria, has consisted in substituting for natural stone, concrete blocks weighing twenty tons each. These blocks will resist wave action when laid on a slope approaching one on one, so that the mound contains much less material than if composed of small rubble. In our American practice, we use the natural rock, but cover the surfaces exposed to wave action with masses quarried to the dimensions of the concrete blocks, thus being able to utilize a cheap material and also reduce the volume to a minimum.

In the accompanying plates are shown cross sections of breakwaters recently constructed at Manila, P. I., and Osaka, Japan, which illustrate these principles. When the Americans occupied the Philippine Islands there was under construction at Manila, a breakwater of the form shown in Section 1. The American extension of the breakwater is shown in Section 2, and the Japanese breakwater

at Osaka in Section 3. In the Spanish project the stone are of comparatively small size. In the American project the stone covering is in masses from 6 to 14 tons in weight. In the Japanese project the covering is of concrete blocks of 8 tons each.



Major Judson estimates the cost of a breakwater in 34 feet of water if constructed of reinforced concrete caissons at \$200 per foot. The contract price for the last extension of the rubble mound breakwater at Cleveland was about \$124 per foot, though built in 36 feet of water.

Whenever it is necessary to have vertical faces to the structures, as in piers at the entrances to rivers, and in harbors of refuge where vessels moor to the breakwater, the reinforced caisson will replace the timber crib now employed for such purposes, but in ordinary breakwater construction the rubble mound it is believed will be found to be the cheaper structure.

In answer to Major Judson's statement, 94 cents was the price bid for quarry run of stone; if you select large stone the cost will be over \$2.00 per ton.

Maj. Judson: With reference to Col. Townsend's remarks, I think it is true that most of the caisson breakwaters shown on the screen could not compete with the rubble-mound breakwater in locations especially favorable for the latter,—for instance, in Lake Erie. There the stone costs something like \$1.00 per ton.

Col. Townsend: If you select large stone it will cost over \$2.00 per ton, but the smaller sizes can be obtained for about 94c per ton.

Maj. Judson: On Lake Michigan, stone up to say 1 ton, costs \$1.40 per ton, while large stone, say 5 to 8 tons each, costs about \$3.00 per ton. Thus a rubble-mound or enrockment breakwater in Lake Michigan would cost about twice as much per lineal foot as in Lake Erie. Again, in Lake Erie, the caisson breakwater mentioned by Col. Townsend as costing \$200.00 per lineal foot, would cost far less. About half the cost was for stone, and the stone was figured at \$1.40 whereas in Lake Erie it would cost but 94c, or even less, as the large stone, which sells at \$2.00, would not be needed and could be removed from the quarry run.

Where rock, both large and small, is cheap, as on Lake Erie, I am disposed to think that a better breakwater could be built at the same cost as an enrockment breakwater by employing shallow caissons for the tops, and reinforced concrete slabs to form the side-slopes of a breakwater otherwise composed for the most part of small stone, as illustrated on Plate XXI. The difficulty of handling, selecting, and placing the large top stone of the enrockment breakwater would be avoided, and under the influence of storms there would, I think, be less displacement. I was for a number of years at Galveston, Texas, in immediate charge of the jetty construction. Nearly 13 miles of jetty was built, in water varying in depth from 0 to 30 ft. These jetties contained some 3,000,000 tons of stone placed almost exactly as Col. Townsend has placed the stone in his enrockment breakwaters. The surface stone, 10 ton blocks of granite, were carefully laid so as to constitute a paving. Nevertheless settlement and wave action, acting independently or together, have caused damage to the Galveston enrockment jetties from time to time, and the cost of their maintenance has not been inconsiderable. I think it is very likely that the cost of maintaining enrockment breakwaters will exceed the cost of maintaining caisson breakwaters, whether the caissons be deep or shallow.

MEMORIAL

MR. GEORGE ADGATE, M.W.S.E.

January 23, 1909.

Mr. George Adgate was the eldest of a large family of children. He was born September 28, 1845, in Keeseville, New York, and died in Kansas City, Missouri, on January 23, 1909; being at that time the Western Manager of the Foundation Company of New York, Chicago, and New Orleans.

His ancestors emigrated from England to Massachusetts and Connecticut during the earliest colonial times. The family has been useful and influential in public affairs throughout its history. His great-grandfather, Judge Matthew Adgate, was a member of the New York Legislature and of the convention which formulated the first constitution of the state of New York. His grand-father and his father were also members of the New York Legislature.

Mr. Adgate inherited a rugged and wholesome physical and mental constitution. He was engaged in public construction continuously from the time when he became a young man and may be said to have belonged to that sturdy class of pioneers who developed and brought to success the art of putting in deep and difficult foundations. At no time during his career was he known to be discouraged or cast down when brought face to face with the difficulties and unsolved problems of the earlier foundation builders. He possessed executive and engineering ability of a high order and commanded the respect and confidence of all his associates and of the engineers for whom he worked, by his sterling integrity and good judgment; to the certain knowledge to the three writers of this memoir, who each had official relations with Mr. Adgate, and now add their testimony of warm regard to that of others.

After his early education at Keeseville Academy, Mr. Adgate spent two years keeping a store in the oil regions of Pennsylvania. After this, he became connected with his father-in-law, Mr. Whitney, who was a contractor on Lake Chaplain, and remained in this work for fifteen years. In 1882 he was engaged by Wm. Sooy Smith & Son as a manager of brige foundation construction, they making a specialty of deep bridge foundation work, and he remained with this firm and its successors throughout the remainder of his busy life. Here his sound judgment and experience were often tested to the utmost, while putting in foundations for some of the largest bridges in the largest rivers of this country, where varying conditions of floods, of its gorges, and of unhealthful sanitary surroundings, had to be anticipated and provided for. In this warfare with the elements he was fortunate enough never to lose a battle. The following bear enumeration of the principal works with which he was connected affords a fairly complete outlook upon the progress of bridge building in the Middle States from 1882 to 1908.

In 1883 and 1884 he was engaged in an executive capacity on the Baltimore & Ohio bridge across the Susquehanna River at Havre De Grace, Md., Wm. Patton, Chief Engineer;—9 pneumatic caissons, 3 open caissons, principal foundations supervised by Mr. Adgate.

1885. Bridge across Trinity River at Fort Worth, Texas, for



GEORGE ADGATE

Gulf, Colorado, & Santa Fe Ry. W. D. Sherman, Chief Engineer. Open caissons, pile foundations.

1885. Bridge across the Arkansas River at Van Buren, Ark., for St. Louis & San Francisco R. R. James Dun, Chief Engineer. 5 pneumatic caissons.

1886. Bridge across the Red River at Arthur City, Texas, for St. Louis & San Francisco R. R. James Dun, Chief Engineer. 2 pneumatic foundations.

1886. Bridge across the Red River at Gainesville, Texas, for Gulf, Colorado & Santa Fe Ry. W. D. Sherman, Chief Engineer. 3 pneumatic foundations and 2 pile foundations. (Abutments.)

1886. Bridge across the Missouri River near Kansas City, Mo., for Chicago, Milwaukee & St. Paul R. R. D. Jenkins, Resident Engineer. 4 pneumatic foundations.

1887. Bridge across the Missouri River at Sibley, Mo., for Atchison, Topeka & Santa Fe Ry. O. Chanute, Consulting Engineer, J. F. Wallace, Resident Engineer. 5 pneumatic foundations.

1889. Bridge across the Colorado River at Needles, Cal., for the Atlantic & Pacific Ry. S. M. Rowe, Chief Engineer. One deep pneumatic foundation—cantilever bridge.

1890 to 1893. Bridge across the Missouri River at Sioux City, Iowa, for the Pacific Short Line R. R. Co. J. A. L. Wadell, Consulting Engineer, Lee Treadwell, Resident Engineer. 5 pneumatic caissons, 2 open steel cylinder piers.

1898. Bridge across the Ottawa River at Ottawa, Ont., for the International Bridge Co. G. H. Massey, Resident Engineer. 5 deep open caissons.

1898. Bridge across the Missouri River at Glasgow, Mo., for Chicago & Alton R. R. W. D. Taylor, Chief Engineer. 3 pneumatic and 2 open cofferdam caissons.

1899. Bridge across the Des Moines River near Boone, Iowa, for the Chicago & Northwestern Ry. E. C. Carter, Chief Engineer. 8 pneumatic cylinder piers and trestle foundations.

1899. Bridge across the Thames River at Chatham, Ont., for Lake Erie & Detroit River R. R. O. McKay, Chief Engineer. Open caissons and pile foundations.

1902. Bridge across the Missouri River at Platsmouth, Neb., for Chicago, Burlington & Quincy R. R. C. H. Cartlidge, Bridge Engineer. One pneumatic caisson.

1902 and 1903. Bridge across the Missouri River at Omaha, Neb., for the Illinois Central R. R. J. A. L. Wadell, Consulting Engineer. 3 pneumatic caissons, 2 deep open cylinders, and 8 open cofferdams.

1905. Bridge across the Kaw River at Kansas City, Mo., for Chicago, Rock Island & Pacific R. R. J. B. Berry, Chief Engineer, A. D. Page, Bridge Engineer. One pneumatic pier, 2 open caissons.

1906. Bridge across the Des Moines River at Harvey, Iowa, for the Chicago, Rock Island & Pacific R. R. 3 open cofferdams, pile foundations.

1908. Bridge across the Mississippi River at Clinton, Iowa, for Chicago & Northwestern Ry. E. C. Carter, Chief Engineer, F. E. Bainbridge, Resident Engineer. 3 pneumatic piers to bed rock, 14 piers on piles in cofferdams.

In addition to this he was the engineer in charge of the building of the present Water Works at Des Moines, Iowa. Built, in 1888, the Crabtree Lighthouse at Bar Harbor, and lighthouse at Deer Island, Boston Harbor, for the United States Government. In 1897 he built a dam across the Apple River at Somerset, Wis., in 1889 a dam across the Montmorency River near Quebec, P. Q., and in 1905 had charge of the foundations of the Inter City Viaduct at Kansas City, Mo.—Wadell & Hedrick, Consulting Engineers.

Personally, Mr. Adgate was kind, just and lovable, and a man of sterling integrity. He was esteemed for those traits by all who knew him and conserved to the last the highest regard of his professional associates, among whom the present writers are glad to be classed, for his ability and character.

He was elected a member of the Western Society of Engineers, June 18, 1901.

He was married September 10, 1866, to Miss Martha Whitney, lately deceased, and leaves a daughter, Mrs. I. R. Dean of New Britain, Conn., and a son, Frederick W. Adgate of Chicago, Ill.

O. CHANUTE,
W. H. FINLEY,
C. H. CARLIDGE,
Committee.

THOMAS TAYLOR JOHNSTON

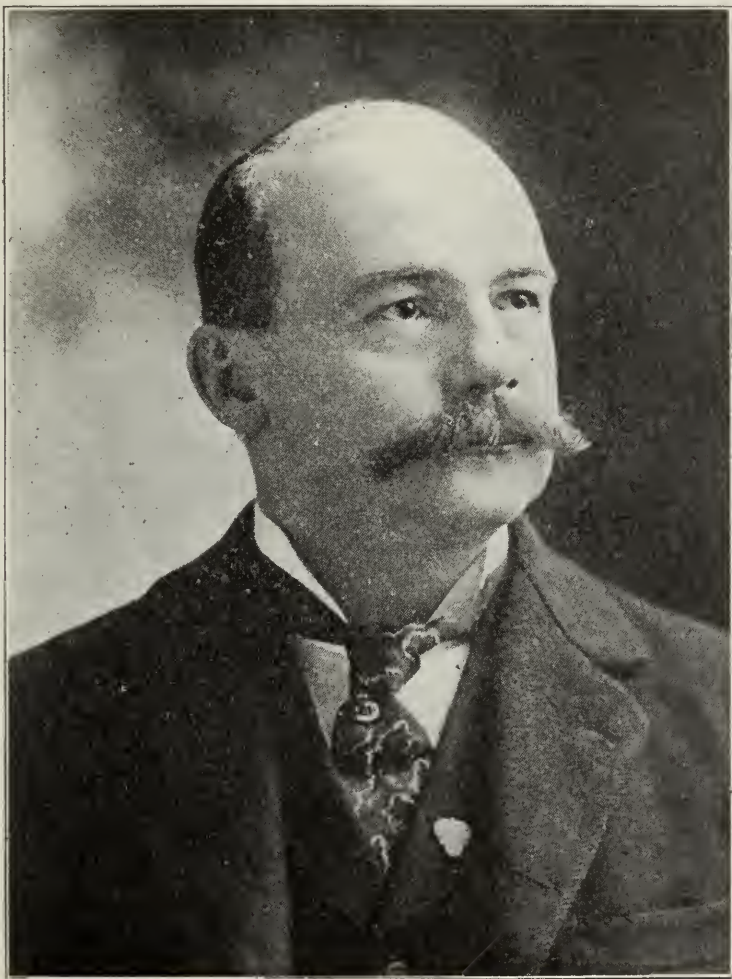
February 22, 1909.

Thomas Taylor Johnston was born in Piqua, Ohio, August 8, 1856.

His boyhood was spent in Washington, D. C., and his early education was obtained in the schools of that city. At the age of 17 he entered the Rensselaer Polytechnic Institute, Troy, N. Y., and was graduated with the Class of 1877, receiving the degree of C. E. His first employment, begun shortly after graduation, was under Col. Casey, Engineer Corps, U. S. A., at Washington, D. C., where he remained for one year. Next he was employed for several months on Government Surveys of the Upper Mississippi River, and in December, 1878, began service on the Mississippi and Missouri Rivers under Major Charles R. Suter, of the Corps of Engineers, U. S. A. He was employed under Major Suter and later under the Mississippi and Missouri River Commissions continuously for about eight years. His first duties were as chief assistant engineer with a hydraulic observation party on the New Madrid reach of the lower Mississippi, stationed at Point Pleasant, Mo. Later he was in charge of the improvement of the Gasconade River in Missouri, but his most important work from a technical standpoint in connection with his eight years of Government employment was his exhaustive study of the great volume of hydraulic data collected

by numerous field parties on the Mississippi and its tributaries. The complete tabulation and study of this mass of carefully collected data, combined with his natural bent for engineering investigation, was the ground work of his remarkable knowledge of hydraulics. The results of his work during this period are liberally set forth in the published reports of the Chief of Engineers of the U. S. Army.

In the fall of 1886 Mr. Lyman E. Cooley, Chief Assistant Engineer to the Drainage and Water Supply Commission of Chicago, having need of special assistance upon hydraulic problems, sent for



THOMAS TAYLOR JOHNSTON

Mr. Johnston and assigned to him the work of making a study of the known experimental data respecting the flow of water in regular channels with a view to its application on the proposed Chicago Sanitary Canal. On this work he was engaged for about one year.

He then accepted an engagement at Memphis, Tenn., and was there employed as Chief Engineer in the construction of the new water works until early in 1890, when on the organization of the August, 1909

first Board of Trustees of the Sanitary District he was again called to Chicago by Mr. Lyman E. Cooley, its first Chief Engineer. Mr. Johnston was placed in charge of the Division of Physical Research and of all observations for obtaining hydraulic data and also in charge of the special studies to determine the most economical proportions for the Sanitary Canal.

In December, 1890, Mr. Cooley ceased to be Chief Engineer, and through loyalty to his Chief, and with a number of other Assistant Engineers, Mr. Johnston resigned and resumed his work at Memphis. Early in 1892, after the re-organization of the Board of Trustees of the Sanitary District, Mr. Johnston returned and continued the work of his former position and completed his hydraulic investigations respecting the channel. These were afterwards printed as a series of extensive tables.

Mr. Johnston later became Assistant Chief Engineer, and had charge of the Division of General Engineering. At times he acted as Chief Engineer. As head of the Division of General Engineering Mr. Johnston had charge of "the preparation of plans for structures; the calculation and determination of all questions pertaining to the hydraulic problems met with in the work; surveys and estimates for all work to be done; the testing of material, flood measurements, etc." He gave special attention to the Desplaines River Diversion and had individual charge of the spillway above Summit. He also had special charge of the design and construction of the Bear Trap Dam and Controlling Works near Lockport.

In 1898 Mr. Johnston's services were in demand for commercial work and his employment was changed to that of Consulting Engineer of the Sanitary District, in which position he continued until about 1900.

Mr. Johnston's connection with the engineering features of the Drainage Canal was important in that from the early study under the Drainage and Water Supply Commission to the putting of the channel in service he was in immediate charge of the study and solution of the important hydraulic problems involved, as well as the design of the important works of construction.

Mr. Johnston's connection with the Memphis Water Works, begun at its inception, was practically continuous either as Chief Engineer or as Consulting Engineer up to the time of his death. He directed all construction work and advised as to improvements and extensions. Under his supervision it has become the largest artesian system in the country, if not in the world. It was the first tunnel gravity system constructed in connection with an artesian supply, and, to quote the present Chief Engineer, "is today a monument to the remarkable boldness of Mr. Johnston's engineering designs."

The Savannah (Ga.) Water Works, an artesian supply involving some of the novel features of the Memphis plant, was designed and built by him, 1891 to 1893.

Mr. Johnston's work in the design and construction of Hydro-Electro Power Plants includes the following: Snoqualmie Falls Plant (Washington), 1898-1900; Economy Light and Power Company's Plant, Jackson Street, Joliet, 1899; Swan Falls (Idaho) Plant for the Trade Dollar Consolidated Mining Company, about 1902 and enlarged in 1907; Oliver Chilled Plow Company's Plant on St. Joseph River, South Bend, Ind., 1904 and 1905. Besides these he was employed in a consulting capacity on a great number of projects and as designing engineer on numerous minor power plants.

The Snoqualmie plant possesses many novel features. The Falls have a vertical drop of 270 feet, as against 163 feet at Niagara, and the banks below the Falls rise in nearly vertical precipices on either side, affording no suitable site for a power house. The power house, which is 40 feet by 200 feet, and located at a depth of about 250 feet below the upper level, was, therefore, cut out from the solid rock about 50 feet back from the stream and about 300 feet above the Falls. It is reached by means of a hydraulic elevator, which, with two 7½ foot steel penstocks, descends to the power house through a vertical shaft. A tail race, 12 feet wide by 24 feet high, leads out 650 feet also through solid rock to the river below the Falls. The gate valves, each weighing 23,000 pounds, were the largest valves in the world operated under such high pressure. The plant developed 30,000 to 100,000 H.P. with a still further increase to 200,000 H.P. possible. The current is carried at 30,000 volts through aluminum conductors to Seattle and Tacoma, 25 and 34 miles away. The many striking features of this plant show Mr. Johnston's characteristic originality of design and fearlessness in carrying out difficult works of construction.

The Economy Plant, built under his direction, includes dam, power house and installation for developing 8,500 H.P. from 13 foot head.

The Swan Falls Plant involved some very difficult problems in dam construction, a reinforced concrete power house with traveling crane, and installation in 1902 for developing 3,000 H.P. from a 19 foot head, and an addition to both power house and equipment in 1907 doubling the capacity of the Plant.

The Plant at South Bend included the entire structural and mechanical equipment for developing 2,000 H.P. under a 15 foot head, and is one of the most compact and modern plants of its kind in existence.

The Kankakee Dam is a reinforced concrete structure of the face and buttress type, 520 feet long and 9 feet high.

In 1900 Mr. Johnston designed and directed the construction of a reinforced concrete aqueduct to carry the Pecos Irrigation Company's irrigation canal over the Pecos River near Carlsbad, N. M. The aqueduct, which is 500 feet long and 20 feet by 20 feet in cross section with reinforced side walls, is carried on four reinforced con-

crete arches. The work is of unique design, and has attracted much attention among engineers.

The Chicago Subway Report, with which Mr. Johnston was connected as Assistant Chief Engineer in charge of the Division to which this work was entrusted, will stand as a monument to his capacity for concise, rapid work. The three Volumes represent a very small portion of the information collected on a variety of subjects from many sources. The Report was printed and ready for distribution in less than six months from the time he received his instructions to supervise this great work.

Mr. Johnston was second Vice President of the Western Society of Engineers, 1895-1896; first Vice President, 1896-1897, and President, 1897-1898. He took an active interest in the publication of the Western Society Journal, contributing many papers, and did much to bring it to its present high standard.

In his profession he was able and energetic, with a high conception of professional integrity and of the responsibilities which his many employments involved. He was untiring in his work and reached his conclusions with care but with remarkable rapidity.

As a friend he was staunch and true. His ideals were of the highest order and he was looked up to by his associates and subordinates alike. He never faltered in his loyalty, and he was ever ready to devote his time and talents to the assistance of others.

Mr. Lyman E. Cooley, under whom he was an Assistant Engineer for some time in his earlier experience, says of him: "He was a loyal and capable Assistant and thoroughly grounded in the technique of his profession. He had great industry and application and a special scent for research in his chosen field. He was self-reliant and bold in his conceptions and confident in their execution. With ripening experience and advancing years he was rapidly taking a position of leadership in our profession."

Mr. Johnston was married shortly after his graduation to Miss Minnie Breüninger, who, with three sons, survives him. His death occurred February 22, 1909, after an illness of one week.

JOHN ERICSON,
E. C. SHANKLAND,
J. H. SAWYER,
Committee.

PROCEEDINGS OF THE SOCIETY

MINUTES OF THE MEETINGS.

REGULAR MEETING, June 2, 1909.

A regular meeting of the Society (No. 666) was held Wednesday evening, June 2nd. The meeting was called to order about 8:30 P. M., with President Allen in the chair, and with but a small attendance—about 35—owing to the inclemency of the weather. The minutes of the meetings of May 5th, May 19th, and May 27th were read and approved.

The Secretary reported from the Board of Direction that at their meeting held June 1st, the following were elected into membership:

George W. Fry, Charlottesville, Va.....	Active
Wm. G. Evans, Chicago.....	Active
C. A. Baughman, Marshalltown, Iowa.....	Active
Edward Zaremba, Chicago	Active
Horace B. McCabe, Chicago	Active
Victor Guillemin, Milwaukee, Wis.	Active
Rudolph F. Kelker, Jr., Chicago.....	Active
Herbert W. Young, Chicago.....	Associate
Wm. H. Petersen, Oak Park, Ill.....	Active
Samuel B. Flagg, Pittsburg, Pa.	Active

Also that the following had applied for membership:

Wm. Rodney Patterson, Chicago.....	Active
Rudolph G. Rosenbach, Chicago	Active
Howard M. Raymond, Chicago.....	Active
Bernard R. McBride, Madison, Wis.	Junior
Tom Russell Wyles, Chicago	Associate

The Secretary presented from the Board of Direction the following correspondence with General Grenville M. Dodge, of Council Bluffs, Iowa:

Chicago, May 18, 1909.

General Grenville M. Dodge, Council Bluffs, Iowa.

MY DEAR GENERAL:

Your services to your country during the Civil War, and in railroad construction in the past, have been so notable that many engineers connected with this Society desire to express, in some way, their appreciation of your work. Accordingly a petition has been presented to the Board of Direction of this Society, asking that you be elected an Honorary Member of the Society, as provided for in our By-Laws, a copy of which goes to you under a separate cover. The Board of Direction has acted upon this petition by unanimously electing you an Honorary Member. It is their hope and desire that you will accept this election and will so advise the Secretary.

May we have the pleasure of hearing from you at your early convenience.

Very respectfully yours,

J. H. WARDER, Secretary.

Council Bluffs, Iowa, May 20, 1909.

Mr. J. H. Warder, Sec'y Western Society of Engineers,
1735 Monadnock Block, Chicago, Ill.

DEAR SIR:

I am in receipt of yours of May 18th, and I wish to say that I appreciate fully the honor paid me by the Western Society of Engineers and I accept it with my sincere thanks.

I know that these organizations are a great benefit to the profession and to the country and have always regretted that I did not, in the early days, join some one of them, but my duties were such that it was impossible for

me to attend them; therefore, I neglected it. So you can see how fully I appreciate the action of your society. My meeting with them was a very pleasant one and I was glad to see the loyalty of the Society. Our profession is one that has never received the credit nor the standing in the United States that it deserves, and this comes from the fact that the members of it have not presented to the public their works. Most of them are connected with railroads and they follow their example, and except for the past few years, it was very seldom that a railroad man defended his acts or went before the public and used the press. I think this is a mistake.

Will you please express to the Society my grateful thanks for the honor they have conferred upon me.

I am,

Truly and cordially,

GRENVILLE M. DODGE.

Referring to the resolution passed by the Society at the regular meeting of May 5th, relating to the appointment of engineers on a "Commission to Revise and Codify the Building Laws of the State of Illinois," a measure before the State Legislature, the President explained what had been done by the Society, including the sending to Springfield of our fellow member, Mr. J. G. Giaver, and asked the Secretary to read a letter from Mr. Giaver, which showed the success of his mission:

Chicago, May 29, 1909.

Western Society of Engineers,
Chicago, Ill.

DEAR SIRs:

As requested by your President, Mr. Allen, I went to Springfield in the interest of the bill now before the State Legislature to create a Commission whose duty it will be to codify the State Building Laws.

I found that the bill, after the first reading, was referred to the Committee on Municipalities. I had it reported out of this Committee and advanced to the third reading in the Senate. It will probably be passed by the Senate today, unless the Senate should retaliate on the House, which last night passed a motion to lay on the table all Senate bills which were before the House on the second and third readings.

As the bill now stands it provides for the appointment of two representatives from the Western Society of Engineers, two from the Architects' Bodies, and one from the Underwriters Association; the State Architect shall be a member of the Commission and act as Chairman of same, one representative from the Builders' Association, and two to be appointed by the Governor at large, making a total of nine members. The Architects will thus have three representatives, and if the representative from the Fire Underwriters' Association is a member of the Engineering Society, as he probably will be, there will be three engineers. If we can then induce the Governor to appoint a man, for instance such as Prof. Talbot, the engineers will be fairly well represented.

Yours very truly,

JOACHIM G. GIAVER.

The text to the bill is as follows:

Section 1. Be it enacted by the people of the State of Illinois represented in the General Assembly: That the Governor be and he is hereby empowered and directed to appoint a commission to be known as "The Commission to Revise and Codify the Building Laws of the State of Illinois," to be composed of nine members selected as follows: One member from the Illinois Chapter of the American Institute of Architects; two members from the Western Society of Engineers; one member representing the National Board of Fire Underwriters residing in this State; one member from the State Board of Examiners of Architects; one member from the Building Contractors' Council; and two members appointed at large. The State Architect shall also be made a member of said commission, and shall act as its chairman: Provided, if the office of State Architect is vacant through resignation or otherwise the Governor shall appoint a chairman for said commission.

Section 2. The duties of said commission shall be to make such investigation into the subject of building laws in force in other states as it may deem necessary, and to consider all the laws in force in the State of Illinois bearing on that subject, with the object in view of revising and codifying the laws of this state which pertain to the subject of buildings. In the report which such commission makes, as hereinafter provided, it shall recommend to the General Assembly such legislation as will properly regulate the construction, sanitation and protection from fire of all buildings of a public nature, or where large numbers of people shall congregate, such as hotels, theatres, schools, churches and other buildings for public assembly, department stores, factories, tenement houses, hospitals, and buildings for charitable, penal and reformatory institutions, so that the greatest measure of safety to life and limb and property may be assured to the people of the State of Illinois.

Section 3. The Commission shall be allowed their traveling and other necessary expenses, and it is hereby empowered to employ a secretary, at a reasonable compensation, not to exceed \$5 per day for each day actually engaged in the service of said commission, and such compensation together with the necessary expenses of said commission shall be allowed and paid, on the presentation of bills, approved by the Governor, out of the funds of the State Treasury not otherwise appropriated.

Section 4. The said commission shall make its report with such proposed legislation accompanying the same to the Governor of this State on or before January 1, 1910.

Mr. W. H. Finley, speaking on behalf of the Committee, consisting of Messrs. Finley, Armstrong, Modjeski, Horton, Allen, Dart, and Prior, which had been appointed to collect data relating to tests to destruction of full sized compression members, stated that so much work had already been done by other societies, and reports published, including the report by the Canadian Commission on the failure of the Quebec Bridge, that the Committee did not consider it necessary to duplicate the work already done and asked to be discharged. On motion the Committee was discharged at their own request.

A motion was made, seconded and carried that the usual meetings in July and August be dispensed with, as is customary.

The President then introduced Mr. J. F. Jackson, M.W.S.E., who presented his paper on "Some Observations on the Stability of Dams." Discussion followed from Messrs. L. K. Sherman, W. H. Finley, F. H. Bainbridge, C. B. Burdick, I. F. Stern, R. J. Mershon, and the Chairman, with some remarks in conclusion from Mr. Jackson.

The meeting adjourned about 9:50 P. M.

EXTRA MEETING, June 16, 1909.

At an extra meeting of the Society (No. 667) was held Wednesday evening, June 16th. The meeting was called to order about 8:30 P. M. with President Allen in the chair and about 75 members and guests present.

There was no business to bring before the Society, so President Allen presented the subject for the evening and introduced Mr. George Weston, M.W.S.E., who read his paper on the "Reconstruction of the Street Railway Tracks in Chicago." Use was made of some lantern slide views to explain the paper. The "Deflector" was also exhibited and explained.

Discussion followed from Messrs. H. B. Fleming, P. E. Green, E. N. Layfield, R. F. Kelker, Jr., C. R. Dart, W. F. Graves, and Mr. Goodenough, with a closure by Mr. Weston.

The announcement was made that the meetings of the Society would be dispensed with until Wednesday, September 1, 1909.

The meeting adjourned about 11 P. M.

J. H. WARDER, *Secretary*.

August, 1909

BOOK REVIEWS

HEAT ENERGY AND FUELS. By Hanns V. Juptner, Professor Imperial and Royal Technical Institute, Vienna, translated by Oskar Nagel, Ph. D. McGraw Publishing Co., New York, 1908. Cloth, 6¼ by 9½ in. Price \$3.00 net.

This is a volume of 300 pages devoted entirely to pyrometry, combustion, analysis of fuels, manufacture of charcoal, coke and fuel gases, etc. The first chapters contain an introduction and a discussion of forms of energy. The specific matter begins with a chapter on Measurement of High Temperatures, followed by others on Pyrometry, Combustion Heat and its Determination, Indirect Methods for Determining Combustion Heat, Incomplete Combustion, Combustion-Temperature, Fuels in General, Wood, Fossil Fuels in General, Peat, Brown Coal (Lignite), Bituminous and Anthracite Coals, Artificial Solid Fuels, Charcoal, Peat-Coal Coke and Briquettes, Cooking Apparatus, Liquid Fuels, Gas Fuels, Producer Gas, Water Gas, and Gas Producers, which serve to indicate the scope of the work. The matter is accompanied by very full mathematical demonstration.

This book, like many others, has been prepared more particularly by a teacher for use in his classes. Its scope, however, has been somewhat extended to make it available for general use outside of the class room, and it is cause for regret that before preparation for publication, the author or translator did not bring the matter up to date. For example, in the chapters on Pyrometry and the Measurement of High Temperatures, no mention is made of the later forms of electrical resistance pyrometers, nor of the pneumatic pyrometer.

The description of methods for determining heat development by combustion is confined to the Mahler and Parr calorimeters, and Bethier's method. This is well, as it excludes a large variety of more or less inefficient apparatus in which the engineer has no interest. No notice, however, has been taken of the recently discovered and now well known errors of the Parr instrument.

While the book, everything considered, is a valuable one, and in fact, the most useful publication of the kind coming to the notice of the reviewer, it is evident that it has been written by one having limited experience in the practical field. For example, on page 229, in Table CVII, giving the composition of lignite briquettes, ash is given as 5.59 to 5.95 percent, without attention being called to the fact that the composition would necessarily vary through wide ranges, due to the employment of material having a variable ash content, and such composition as presented would have application only in the specific instance quoted.

A. B.

REMAKING THE MISSISSIPPI. By John Lathrop Mathews. Houghton Mifflin Co., Boston and New York. 1909. 265 pages including index, with illustrations. 5½ by 8 in., cloth, \$1.75 net.

In the present very general interest in waterways and the "Conservation of our Natural Resources," this book is very opportune and full of interest to an intelligent reader at all concerned in the above subjects. The book has some illustrations and gives a very comprehensive mental picture of the great Mississippi Valley which includes all of the drainage area of the "Father of Waters." There is not too much of the technical for the general reader, and for this reason the army engineers who have been engaged on the improvements of the Ohio, Mississippi, and Missouri Rivers may not find the work of much value to them, yet they could not deny the charm of style and manner of the author, and might obtain a wider and more comprehensive view of what has been done in the remaking of the Mississippi river.

Some of the chapter headings are: "The Mississippi System," "The Hydrology of the System," "Controlling the Major Bed," "Levee Building and Maintenance," "The Minor Bed and Regularization," "The River Mouth," etc., with a chapter on "The Lakes to the Gulf," a subject of much importance

and which has been discussed many times before this Society. The chapter on "The River Mouth," is a fine tribute to the genius of that great engineer, Capt. J. B. Eads, and explains quite fully what he planned and accomplished.

The fundamental differences of the characteristics of the Ohio, the Upper Mississippi, the Missouri, and the "lower river" are clearly put forth and the necessity of change in the engineering work, required by these different conditions. The author states forcibly the necessity of the treatment of all of the waterways and tributaries of this great valley, extending from the Appalachians to the Rocky Mountains, and from the Great Lakes to the Gulf of Mexico, in a broad comprehensive manner, which should include the formulation of a standardization of the work to be done on the various tributaries, according to their extent and character. The possibility of financial return, through hydro-electric projects, on the great outlays of the federal government in these river improvements, is brought out. Some idea of what these river improvements have cost the country in actual cash outlay is shown in sundry tables of expenditures.

The book is well printed, is pleasant to handle and delightful to read by one who desires to have an intelligent understanding of this great subject.

[Those interested in this subject will find two valuable papers in the Transactions Am. Soc. C. E., Vol. LXIII, June, 1909,—viz.: "The Floods of the Mississippi Delta; their Causes and Suggestions as to their Control," by Wm. D. Picket, and "Improvement of the Ohio River," by Wm. L. Sibert.]

SIMPLIFIED METHODS OF CALCULATING REINFORCED CONCRETE BEAMS. By Noble Twelvetrees, M. I. Mech. E.; A. M. I. E. E.; M. R. S. I. Author of Concrete-Steel, etc., etc. 5 by 7 ins. Paper binding. 20 pp. 3 tables. 4 diagrams. 5 illustrations. Macmillan & Co., New York. Price 20 cents.

Some three years ago the writer had the pleasure of reviewing Mr. Twelvetrees' book on Concrete-Steel for this Journal. The present pamphlet is for the purpose of bringing that little book into line with modern practice in nomenclature for reinforced concrete design. An attempt is being made in Great Britain to get everyone into line, and seemingly with considerable success. In the United States we seem to have settled pretty well on the nomenclature of Professors Talbot and Turneaure, but the proposed standards for British engineers do not differ much from these. There are a few differences, however, that are so simple that little confusion will result in reading English books on concrete, hereafter. Where it is customary in this country to use *fc*, the new British standard will be *cc*. For our *fs* they will use *ts*. Where we use *j* to represent the moment arm, they will use $d(1-x)$. Where we use *k*, they will use dx . In this connection it is well to point out that Prof. Turneaure and Maurer use *x* to denote distance in inches down to the centroid of compression, whereas the *x* of Mr. Twelvetrees is a ratio. Where we use *n* to represent the deformation ratio, the British engineers will use *m*.

It is a good thing to see a method at last adopted in England where there are no Greek letters used. In many of their books they are used so freely, that it is hard to follow a discussion.

In this book Mr. Twelvetrees describes a new device he has patented for making reinforced concrete calculation, viz., an improved form of slide rule similar to many in use in the offices of American designers. E. M. C.

AZIMUTH. By George S. Hosmer, Mass. Institute of Technology, Boston. John Wiley & Sons, New York, 1909. 73 pages. $4\frac{1}{2}$ by $7\frac{1}{4}$ in., leather. Price \$1.00

This little hand book is small enough to carry into the field, yet it contains all that is necessary to enable the surveyor or engineer when out on a survey, to determine the true meridian, or declination of the magnetic needle at the place of his work. Of course such determinations are based on as-

tronomical observations of Polaris (or some other star) or of the sun. Methods for taking these observations and making the necessary calculations are given in the book.

"The purpose of the volume is to present in compact form certain approximate methods of determining the true bearing of a line, together with the necessary rules and tables arranged in a simple manner, so that they will be useful to the practical surveyor."

The first half of the book is descriptive, explanatory, and instructional and with a few illustrations, but needs careful reading as the matter is somewhat condensed. The surveyor or engineer should have had some study in astronomy to readily follow the author. The second half of the book consists of tables for use in making such observations, etc., as described. These include certain logarithmic tables to aid the field calculation; corrections for Azimuth, of the sun's declination, etc., etc. These include a table (9 pages) for the Sun's Declination at Greenwich mean noon for every day of each month for the years 1909-1912, inclusive. Some miscellaneous tables and rules at the end of the book make it that much more complete. Altogether the book is a convenient one for field or office use to those engaged in Geodetical work and well worth the price. W.

"RAILROAD STRUCTURES AND ESTIMATES." By J. W. Orrock, C. E. VI+270 pages; 93 figures. 6 by 9. cloth. John Wiley & Sons, New York. Price \$3.00 net.

This work is a compilation of data relating to structures required for operating a railroad, the materials entering into their construction and approximate estimates of costs, together with a general description of the structure and its purpose.

As a reference work, it is complete in its scope, but the treatment is very general and in some case limited, as it must be in a work covering such a broad subject. There are nine chapters, a table of contents, and an index of over 600 references.

In Chapter 1, the author gives approximate quantities and cost of grading, clearing, track material, track laying, ballasting, switches, etc. Chapter 2 gives approximate quantities and costs of all kinds of fencing, gates, signs, road crossings, etc. Chapter 3 gives approximate quantities and costs of culverts. Under pipe culverts, the table of quantities and costs cover diameters from four inches to twenty-four inches for tile and cast iron pipe and diameters from eighteen inches to thirty-six inches for concrete pipe. In present day practice, cast iron pipe from thirty-six inches to forty-eight inches in diameter is common, and sixty-inch pipe is used. The author states that tile (meaning vitrified pipe) should have at least four feet of embankment on top and cast iron pipe ten feet. This is strange information when sixty-inch cast iron pipe is successfully laid under five feet of embankment. Reinforced concrete culverts are not mentioned except as the author refers to the old style rail top culvert as having a reinforced top.

Chapter 4 is devoted to bridges, trestles, retaining walls, cribs, and tunnels. Diagrams are given of the usual type of steel railway bridges, with tables of approximate weight and costs. Tables are also given for estimating yardage in abutments and piers, of various heights, and the timber in pile and trestle bridges of various spans and heights. A simple rule is given for estimating steel trestles for any given opening. Subways, overhead crossings, retaining walls, cribs, and tunnels are each given very limited space.

Chapter 4 covers buildings and it is the best and most complete chapter in the book; the author either being more familiar with this branch of the subject or more fortunate in his selection of data. Tool houses, section houses, shelters, platforms, freight sheds, engine houses, oil houses, coaling stations, ash pits, turntables, and many other structures are illustrated, and approximate estimates and costs of each are given, including the usual fixtures and furniture of each. Chapter 6 covers water stations with approximate costs of pumps, boilers, piping, tanks, and the other usual necessities of such

stations. The tables in this chapter are those usually found in the back of trade catalogs. On page 186, the author gives an example of how to determine the quantity of water delivered per minute with a certain pump based on these tables. Such a method is a poor kind of guess-work, and it is too bad to perpetuate such misleading information.

Chapter 7 gives approximate estimates and costs of railway shops, covering the various plants required and their equipment. The chapter is short but good. Chapters 8 and 9 are given over to specifications, contracts, plans and estimates, and estimating notes.

In many cases, the type of structures given are not typical but local. They are probably mostly Canadian Pacific standards, as the author makes acknowledgment to that road for use of their illustrations. Naturally many of these structures are a development due to the latitude in which they have been built, and are not applicable to a more temperate climate. The same may be said of the estimates of cost—they are as a rule high but are tabulated, and the labor and material separated so that alterations can be made to suit other conditions.

The work as a whole is a very commendable compilation and will be found of considerable value where general, rather than specific technical information is desired.

G. H. H.

GENERAL LECTURES ON ELECTRICAL ENGINEERING. By Dr. Charles P. Steinmetz, Past President A. I. E. E., Consulting Engineer General Electric Company, Professor of Electrical Engineering Union College. Robson & Adey, Schenectady, N. Y., 1908. 6 by 9 in. 284 pages. Cloth. Price \$2.00.

This book, as the title and preface indicate, contains a series of seventeen lectures and two appendices, general in their nature and dealing with the problems of generation, control, transmission, distribution and utilization of electrical energy.

The treatment throughout the book is wonderfully clear and concise and while there is a number of simple diagrams and curves there is practically no mathematical discussion whatever. This fact, together with the weight of eminent authority on matters electrical that is so universally accorded to the brilliant and versatile author, makes the book of great value, not only to the electrical engineer but to the engineering profession in general and also to the interested layman.

Each of the lectures treats of a distinct subject in the field of electrical engineering, thus making the book convenient for ready reference. The lectures are essentially descriptive and while necessarily somewhat general they contain many specific examples and illustrations of the best and most modern practice.

The first lecture is a general review of the art of electric power generation and utilization and the subsequent intermedial steps of transmission, conversion and distribution. The underlying reasons for much of the original and subsequent development are given and also a clear statement of the advantages and disadvantages of methods and standards.

The second and third lectures deal respectively with general distribution and light and power distribution. The actual operation of a direct current and an alternating current distribution system is discussed and illustrated by diagram. Some typical examples are given and quantitative results worked out with all of the various combinations of single phase and multi-phase circuits.

Load factor and cost of power in the fourth lecture is an exceptionally clear and concise explanation of this much misunderstood subject. In the fifth, sixth and seventh lectures are treated Long Distance Transmission, Higher Harmonics of the Generator Wave and High Frequency Oscillations and Surges, in a manner to give the reader a fund of usable and up-to-date information and (considering the complexity of the subjects as ordinarily discussed) of an almost intensely practical nature.

The eighth and ninth lectures include a comparison of prime movers and in some detail the advantages and disadvantages of the hydraulic turbine, the

steam engine, the steam turbine and the gas engine. The characteristics of electric generators and their protection and operation are explained, especially the hunting of synchronous machines, motors, converters and generators and a cure is given for each.

The regulation and control of direct current and alternating systems with various kinds of apparatus is discussed in the tenth, and lightning protection in a very interesting manner in the eleventh lecture.

The twelfth, thirteenth and fourteenth lectures, deal with the Electric Railway, railway motors in general and the alternating current railway motor. The last mentioned is a very clear lecture and quite analytical considering the limitations of space.

Electrochemistry in the fifteenth is treated 'under various divisions but all primarily as an application of electric power. In the sixteenth and seventeenth lectures the various forms of incandescent and arc lighting are explained and considerable specific information is given. Appendices I and II contain papers previously presented but now revised to date on Light and Illumination and on Lightning Protection. Both appendices contain much of the latest information on these subjects, considerable of which is believed by your reviewer to be the author's original work. P. J.

EXERCISES IN SURVEYING, for Field and Office Work for use in connection with "Plane Surveying," by John C. Tracy, Sheffield Scientific School, Yale University. 12mo., 183 pages, 5 by 7½ in. Leather bound. Price, \$1.00. New York, John Wiley & Sons, 1909.

The earlier work, "Plane Surveying," by Prof. Tracy, issued by the same publishers a year ago, was reviewed in this JOURNAL, December, 1907, Vol. XII, page 845.

The supplemental work contains a wide range of exercises for the instruction of the student of surveying. It consists of Part I, "Field Work," (including class room introductory exercises) and Part II, "Office Work." These exercises necessarily refer to the text-book by page, section, etc., and if thoroughly worked out by the student, will give him a very good training in his profession, as far as this can be accomplished in advance of responsible charge of actual work. The arrangement of exercises is based on the author's theory that this study should be a gradual development with the specific study of each detail and method, accompanied by field work. The field work covers chaining, use of transit, running of transit lines, and making transit surveys, exercises and special problems of leveling, exercises in the use of the compass, the stadia and the plane table, topographic surveying, the determination of a true meridian, etc. In Part II, relating to "Office Work," is the matter of computation, calculation of bearings, latitudes and departures, triangulation, areas, earthwork calculation, platting, etc. The exercises are very complete, with frequent reference to the text-book "Plane Surveying," but in some courses, the instructor may find it advisable to eliminate some of the work. The book is essentially a text-book and would not be of much value to a regular practitioner, though doubtless of interest to look over to see what is recommended to the present day students. W.

Journal of the Western Society of Engineers

VOL. XIV.

OCTOBER, 1909.

NO. 5.

SOME OBSERVATIONS ON THE STABILITY OF DAMS

By J. F. JACKSON, M.W.S.E.

Presented June 2, 1909.

In view of the rapidly growing interest in the subject of water power development and reservoir storage of water for various purposes, it has seemed to the writer opportune to present for discussion some more or less unorthodox observations on the manner of calculating and constructing the various generally accepted types of dams.

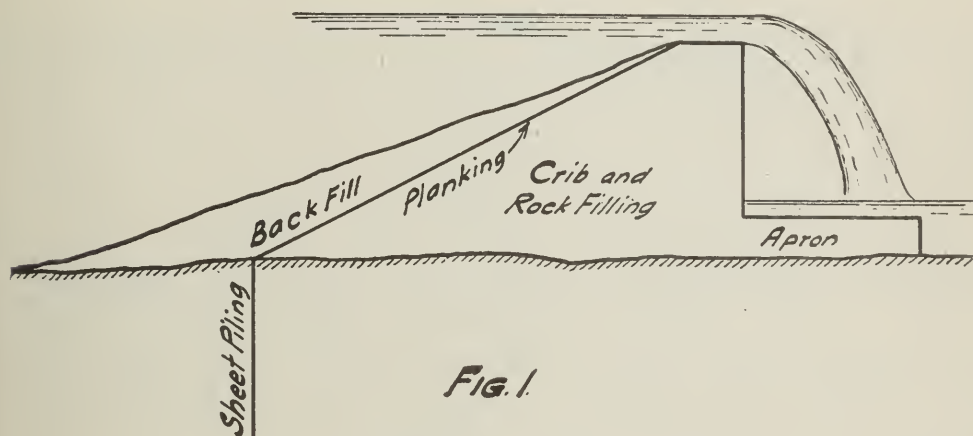


FIG. 1.

Cross Section of Timber Dam.

In the old-fashioned timber dams, hundreds of which have been built for logging and power purposes, on all sorts of foundations, it was customary to give the water-tight surface of dams a slope upstream, generally two or more horizontal to one vertical, making a cross section something like Fig. 1 in the case of an overfall dam. In case the height was considerable, the apron would be divided into two or more steps, to break the fall of the water.

For the purpose of a coffer-dam of moderate height on solid rock or impervious bottom, the same general idea is satisfactory, as shown in Fig. 2.

In this diagram the planking is shown laid at slope of one to two. Note the position and direction of the resultant of water pressure. Little theoretical study, as far as the writer knows, has been given to these forms of dams.

It is obvious in each of the above cases that the weight of the water and the back filling have been a large or the entire factor in the stability of the dam, both against sliding and overturning. "Castor Fiber," who belongs to the oldest race of dam builders, has always utilized the weight of water for stability, and some of his achievements have been truly remarkable. The lower part of his dams are always open for drainage. The writer contends that his work is more scientific than that of some of our modern builders, as will be demonstrated later.

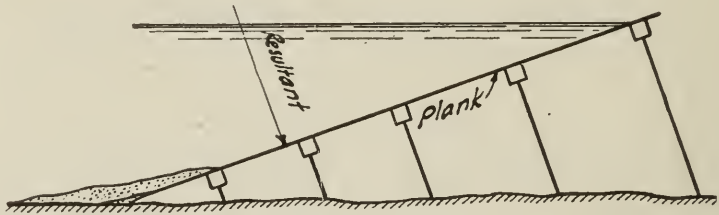


FIG. 2

Cross Section of Cofferdam for Shallow Water.

Now when it comes to the construction of masonry dams, the first ones were probably built entirely by guess, but some of them stood up. A precedent having been established, in course of time, mathematicians came along and found that masonry structures having a factor of safety of two against overturning and of one against sliding on their bases were actually standing up. Therefore a coefficient of friction of 0.6 or 0.7 was assumed, and a sufficient weight of masonry provided to resist the horizontal hydrostatic pressure of the reservoir. Hence we have the standard triangular or trapezoidal section as shown in Fig. 3, in which the resultant pressure of water and masonry usually falls just inside or at the middle third of the base, so that pressure begins practically at zero at the inner heel and increases to a maximum at the outer toe, as illustrated above, provided the structure acts as a unit. The pressure of water and weight of masonry are such that the coefficient of friction is barely sufficient to resist sliding. In fact, if it were not for the dove-tailing into rock at the base of the dam and into the walls of the gorge between which the dams are built, there would be many more failures by sliding than there have been. However, so far as mathematics are concerned, we have the astounding fact that in masonry structures of immense importance, and in perhaps no other cases, engineers are content to follow in the rut and build with a factor of safety of *one*! So much for precedent. Further than this, as soon as you assume hydrostatic uplift, or that water enters under the edge "A" of your dam, your precious friction coefficient is partially destroyed, and the dam fails. It is only fair to say that most engineers now make some attempt to drain toward the downstream toe of the dam. (See Transactions of Am. Soc. C. E. Vol. 34. Notes on High Masonry Dams by John

D. Van Buren, for argument in favor of a section of masonry dam taking into account hydrostatic uplift.) Of course, the form of masonry dam is somewhat circumscribed by the fact that no tension is assumed on the upstream face, but the writer nevertheless believes it quite possible to develop a form of masonry dam in which the weight of water and possible back fill is utilized to add stability, and may propose something of that sort in the future. He surely believes that the ordinarily accepted coefficient of friction as indicated above and the factor of safety of two against overturning, should not be accepted as sufficient.

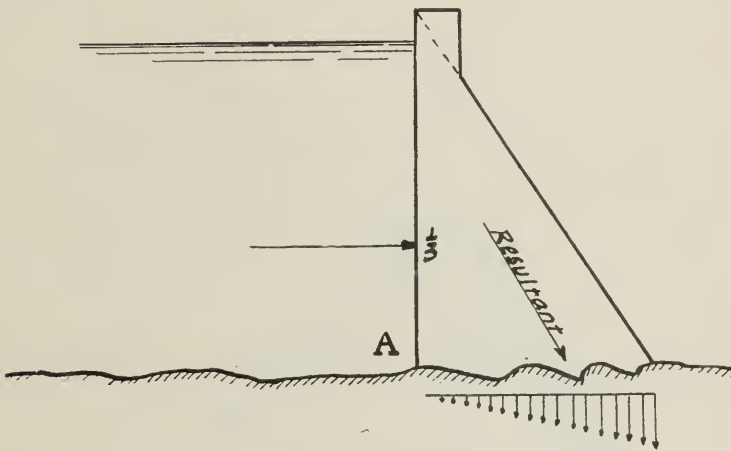


Fig. 3

Typical Cross Section of Masonry Dam.

In earth dams, the writer believes, of course, that the section should be something like that shown in Fig. 4.

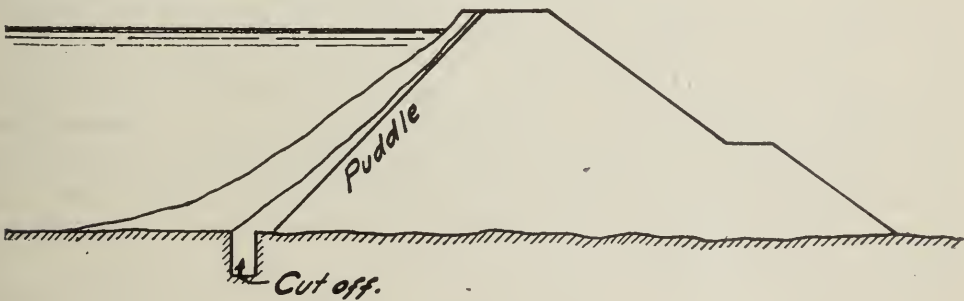


Fig. 4.

Typical Cross Section of Earth Dam.

The same idea applies to an earth dam, a rock fill dam or like structure with a cut-off planking, reinforced concrete, steel plate, or common puddle. In every case water-tightness should, if possible, be secured as near the water itself as possible, and the vertical components of the hydrostatic pressure should be equal to or exceed the

horizontal ones. Western engineers have already followed this idea to some extent in earth and in rock fill dams with planking.

Designers of concrete dams have usually followed the standard masonry profile or something near it. It is human nature, in engineering matters as in other affairs, to follow and develop an established idea, sound or unsound, to its utmost limits, while a new one or a very old and forgotten one, must make its way slowly.

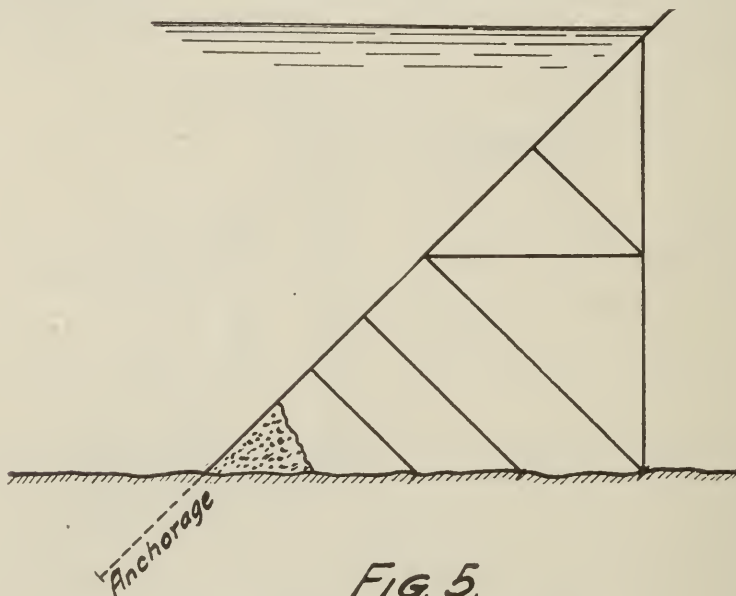


FIG. 5.
Cross Section of Bainbridge Steel Dam.

Happily, Bainbridge with his steel dam, and Ambursen with his concrete dam, and the idea of the reinforced concrete retaining wall came along, so that it is now in order to consider a dam having a water-tight face capable of taking tension. Bainbridge's dam consists of a series of inclined bents covered on the upstream side with water-tight concave plates. (See Journal W. S. E. Vol. X, p. 615.) In this dam, water pressure is of course taken normal to the water-tight face (Fig. 5). The column loads are taken directly to the rock bottom, and tension of face plates is taken up by anchor rods, as indicated. If not founded on rock, the design must be altered radically, as indicated further on.

Although the Ambursen dam (Fig. 6) utilizes the weight of water to some extent, in my opinion it does not, as ordinarily constructed, provide much greater stability against sliding than the standard profile, though it does thoroughly provide against hydrostatic uplift by the open construction of its base. The main idea of Ambursen's patent was apparently to so construct the water face of his dam with reference to the cross walls that the direction of water pressure at any point should fall within the base.

Of course, the calculation of stability of a steel dam on rock bottom, with given factors of safety, is very much simpler and more

certain than even the design of a steel railroad bridge, and the writer believes that the time is coming when the merits of this construction will be much more appreciated by engineers than is the case at present.

In designing the cross section of a steel dam about 100 ft. high, the writer accidentally hit on the idea of making the part near the top, where hydrostatic pressures are light, nearly vertical, and sloping the part near the bottom, where hydrostatic pressures are heavy, until it was nearly horizontal. This resulted in a saving in construction cost, and a greatly increased factor of safety against sliding and overturning.

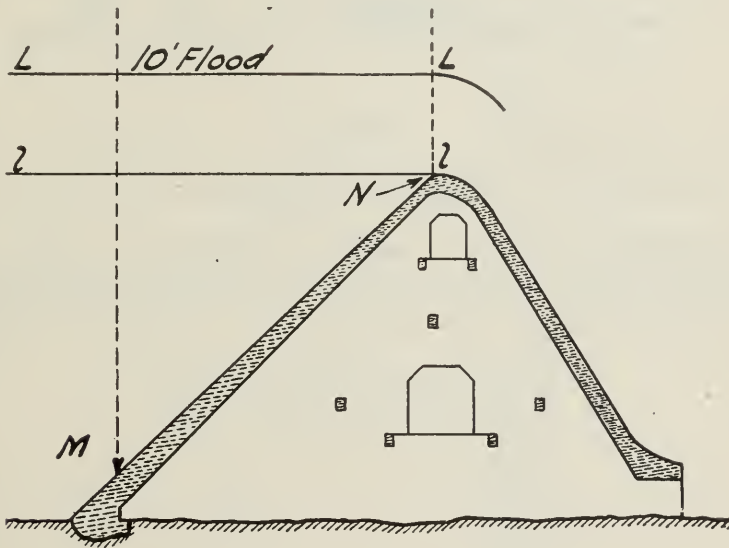


Fig. 6.

Cross Section of Ambursen Dam.

The idea is illustrated in Figs. 7 and 8, where the plating on the lower section is supported directly in concrete, cheap masonry, or other filling, while the upper part is of steel construction. The amount, position, and direction of resultant pressures depend on the exact shape of the water-tight surface. The vertical water pressure may be made 1.5, 2, or even 3 times the horizontal pressure, depending on the width of base; and the resultant pressure of all, weight of water and structure, may be brought as near the center as desired. In Fig. 7 is shown a dam of considerable height, and in Fig. 8 one of moderate height.

The limits of this idea are shown in Fig. 9. Suppose we have a dam built of a small bent plate: calling the height 24 in., the base 14 in., the horizontal water pressure would be 2, applied at 8 in. from the base; the vertical pressure would be 2.33, applied at 7 in. from the bend. The resultant would be 3.1, applied practically at the bend. The structure would be just a little more than stable against over-

turning, and a friction coefficient of 0.86 would be sufficient to prevent its sliding.

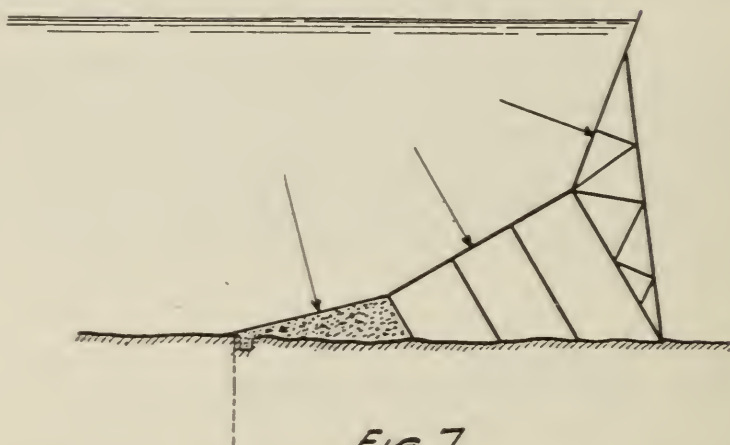


FIG. 7.

Cross Section of Suggested Concrete and Steel Dam.

In case the base were 24 in. and the height 24 in., as in Fig. 10, the horizontal water pressure would be 2 as before, and the vertical pressure would be 4, and the resultant 4.5, falling at a point one-

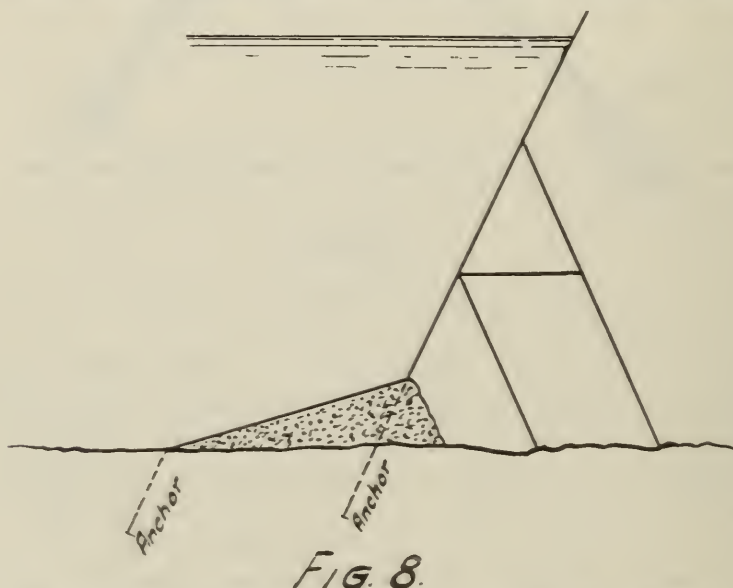


FIG. 8.

Another Suggestion for Concrete and Steel Dam.

third of the distance from the bend to the upstream edge of the horizontal plate. This resultant would stand two vertical to one horizontal, giving a coefficient of 0.50 to just prevent sliding. If you prevent leakage at "A" and your plate is stiff enough to prevent bending, you will have, due to water pressure alone, a small dam as safe against overturning and safer against sliding than the standard profile. It is evident, then, that in a dam having a base equal to its

height, the sum of all horizontal pressures is exactly that due to the depth of the water, no matter what the shape of the water-tight

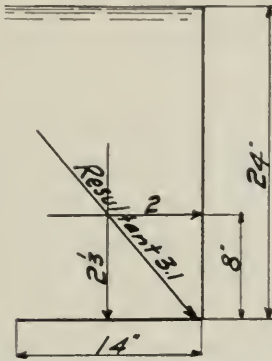


FIG. 9.

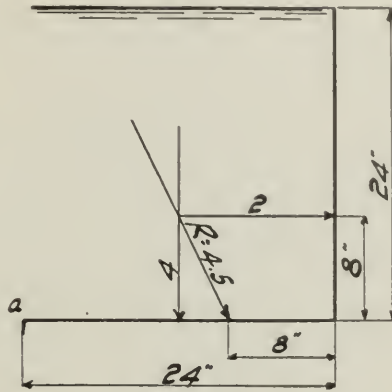
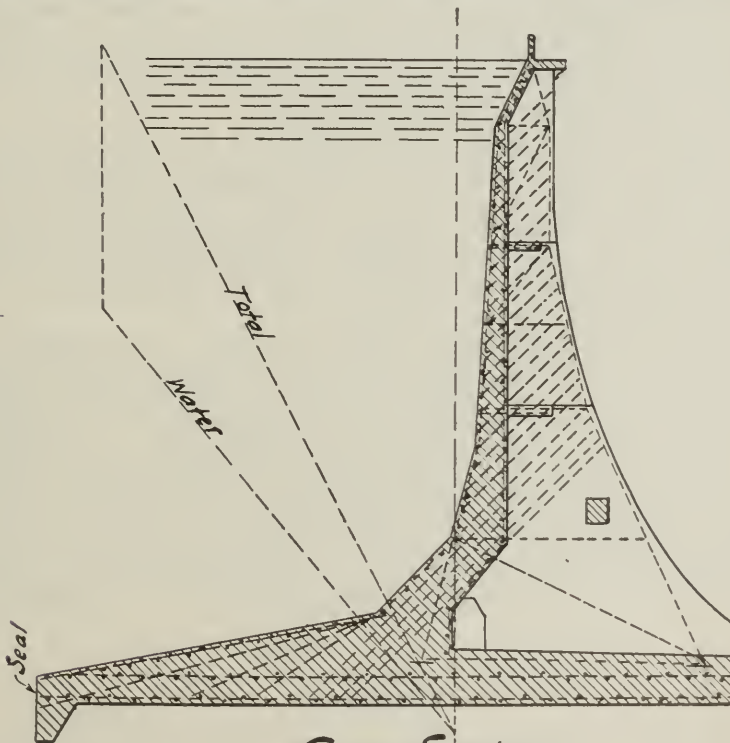


FIG. 10.

Cross Sections Showing by Bent Plates the Principle of Dam Suggested by Author.

surface, and it is possible to utilize the vertical pressures from a minimum of zero to a maximum of two times the sum of the hori-



Cross Section
FIG. 11.

Proposed Typical Section of Reinforced Concrete Dam Suggested by the Author.

Pat. Nov. 3, 1908.

zontal forces, and to bring the resultant of both forces from a horizontal direction to an inclination of two vertical to one horizontal, as shown. Of course, in the practical structure of steel of the Bainbridge type or of concrete, wood, or other material, we would curve the tension face in some manner, and in making our calculation add the weight of the structure itself.

In Fig. 11 is shown the proposed section of a reinforced concrete dam having a concave water-tight face. Please note the position and direction of the resultant of the water pressure and also note that the total resultant falls about half way between the center and the $1/3$ point. It is designed to be a very heavy and substantial structure, but contains only about one-half the amount of concrete of that required in a dam of standard cross section.

In this particular case the water pressure resultant stands at an angle of five vertical to four horizontal, and the total resultant at eleven vertical to five horizontal, and the structure very evidently has some stability against both overturning and sliding. A spillway section employing this principle also works out very favorably in either steel or concrete.

The patent office has recently recognized this principle of using hydrostatic pressure on a concave face to add stability to dams, etc. So far as the writer knows, this is the first recorded recognition of the hydrostatic principle involved. He does know, however, of a mining engineer out West who once built a small concrete dam wrong side to, and with very good results.

The modern inside buttressed reinforced concrete retaining wall employs a similar idea, but the earth pressures are not hydrostatic. In the earthen dam with masonry core wall, the hydrostatic pressure against the core is of course greatly modified (but nobody knows how much) by the presence of the earth fill on the water side. Its design is eminently a matter of guess work.

In conclusion, my contention is that a factor of one against sliding is not enough, and that we should turn the hydrostatic force to our assistance, instead of working entirely against it. We must have weight to secure stability, and there is nothing for that purpose quite so cheap as the water itself which we are undertaking to confine.

If the above observations on dam stability of various new and old sections provoke spirited discussion of the ideas involved, the writer believes that a service will have been rendered the engineering profession.

DISCUSSION.

President Allen: It may be in order to state, for the enlightenment of those who do not know, that "Castor Fiber" is the scientific name for the common beaver.

This paper of Mr. Jackson's is a very timely one, not only from the interesting character of the construction problem, but from the underlying principles in connection with it. He has attacked established

customs that have grown up from the "rule of thumb" method, and has given us, instead, a scientific method of utilizing the forces at hand to accomplish the result. There is altogether too much of the "rule of thumb" method, even among those who are qualified to do better, and the more papers we have to bring out the real groundwork of engineering principles, the better we are serving the profession in general. The paper is now open for discussion.

F. H. Bainbridge, M.W.S.E.: In regard to this French type of dam, such as the Quaker bridge dam, that Mr. Jackson facetiously refers to as having a safety factor of *one*, that factor really does not obtain in the legitimate cross section of the dam on which calculations are made. It is experimentally shown that the hydrostatic pressure as an uplift occurs at the toe and may occur at any joint. Practically every dam of this character which has been built with this straight top has failed, and those that have not failed have succeeded because they have been arched. That is all there is to it. It is supposed to be scientific in a way, but it is not. It neglects an essential factor in construction.

With regard to types the writer shows here, there is a general objection to some of them under certain conditions, on account of the fact that they do not take care of the ice question, which is a very serious thing. In the Quaker bridge dam, when there is any likelihood of ice of any thickness, a force of men is constantly employed to cut it away. In the Bear Valley dam a large force is maintained when there is any tendency of ice to form. They never allow any pressure of ice against the face of the dam. That is a question of maintenance.

I want to take up the question in a paper prepared by the speaker in 1905, which was discussed by Mr. L. E. Cooley, of this Society. At the close of the discussion, is the following:

Lyman E. Cooley, M.W.S.E.: The dam is the most important and responsible class of structures which the engineer is called upon to design and construct. It develops a natural resource and produces population which come to depend thereon in the most fundamental way, as in works of irrigation, for water power, for the supply of cities, and for protection of land. Such work should, therefore, have all the elements of permanence and safety which the engineering art will permit. The menace of inferior structures is so enormous and the results of failure so complete that the merely human element involved in the operation and care for the dam should be eliminated as far as possible.

"I therefore do not sympathize with the present tendency toward bric-a-brac structures, and if it should continue, corrective legislation on the part of the state should be invoked. I do not mean by this that frail or perishable structures may not be expedient for temporary service in new and inaccessible regions where population is sparse and the results of fail-

“ure chiefly affect the owners of the dam. Nor do I mean
“that certain classes of design shall not be admitted as auxil-
“iaries in situations where failure will not produce results ap-
“proaching a disaster.

“I regard steel as one of the most perishable materials for
“hydraulic work, requiring extraordinary care in its junction
“with the bottom and sides of the dam site and constant solici-
“tude in maintenance.”

The writer of this criticism assumes that stone is indestructible and that steel is extremely perishable under the circumstances, whereas the contrary is true. Take granite, quartzite, siliceous sandstones, trap rock, etc.,—they are, for all practical purposes, indestructible, but they are not available for dam construction, and the stones which are available are very destructible. Take the Illinois Central abutments at Sixteenth Street which were put in about 1892; they are on the verge of going, but the steel structure is there practically untouched. At Sixtieth Street on the Illinois Central R. R., the abutments there were cut to pieces and replaced in 1904, while the steel structure was untouched.

At a recent meeting of this society, on the subject of protective coatings, I exhibited a specimen of an iron bar which had been placed in the Mississippi river in 1863, which was painted on one side only with one coat of red lead. That specimen is here now and it is practically untouched by corrosion. A good paint, under water, will last indefinitely, and that has been proved over and over again.

Further referring to Mr. L. E. Cooley's discussion of the paper which I presented before the Society in October, 1905, it will be found that Mr. Cooley's practice does not agree with his preaching. As Chairman of the Engineering Committee of the Sanitary District of Chicago at that time, Mr. Cooley is mainly responsible for the construction of the Bear Trap Dam at Lockport, a *steel* structure. This structure closes an opening 160 feet wide, with a possible head of water of 35 feet and a normal head of 22 feet. The failure of this structure would wreck all the shipping in all branches of the Chicago River at the time of failure; it would wreck most of the bridges in the Chicago River and many on the Canal; all the heavy building, including elevators and their contents, along the Chicago River and its branches would be precipitated into the river. The failure of the Bear Trap Dam at Lockport would, in a word, result in a great loss of life and the destruction of hundreds of millions of property. The Bear Trap Dam is exposed to the sewerage and acid laden waters of the Chicago River and is far less defensible as an engineering structure than anything Mr. Jackson or the writer has proposed.

The difficulty of obtaining a junction between the steel structure and the bed rock, as mentioned by Mr. Cooley, does not obtain in fact. This junction can be made absolutely secure and water tight

at a moderate expense, as has been done at the Ash Fork Dam, which is partly founded on volcanic cinder. It should also be noted that the North Sea Canal, the most important canal now in operation, is controlled at its ends by movable steel dams and that these are subject to the action of sea waters.

L. K. Sherman, M.W.S.E.: The Sanitary District of Chicago is about to build a little dam on the north branch of the Chicago river, where it will empty into their North Shore channel.

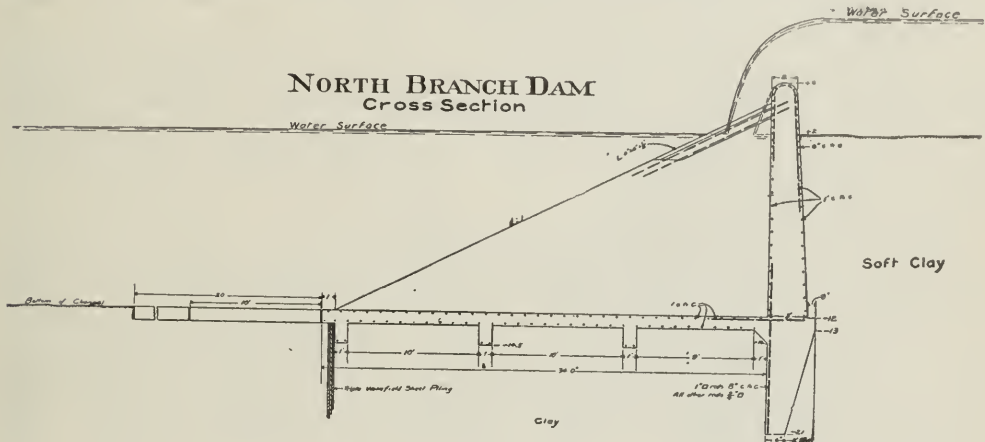


Fig. 12.

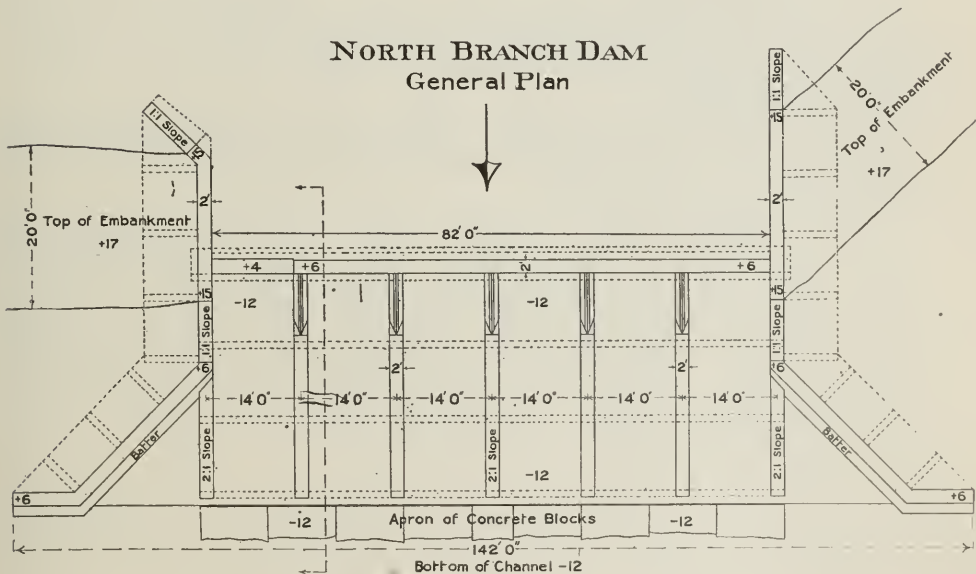


Fig. 13.

The illustration shows a plan and cross-section of the dam; some of the features are somewhat novel. Here is the situation: the north branch of the Chicago river comes in at a higher elevation than the ordinary water in the canal. In order to prevent erosion in the Canal we will have to build a spillway. The site is on clay,

which is rather soft, and consequently we have made a spread foundation; we had to put in an apron to prevent erosion, and we utilized the apron to add to the stability of the structure. The dam consists of a straight wall, with buttresses spaced about 14 ft. apart and 2 ft. thick, all reinforced concrete. All of the horizontal force is taken up, not by any friction on soft clay but by the heel of the dam which extends below the floor or apron. We consider the friction on clay as zero. In fact the dam might slide down stream of its own weight if the clay strata happened to dip in a down stream direction. All the horizontal force is taken up by this foundation part of the wall, and all of the unit pressures are less than one ton per square foot. At one end some Wakefield tripple sheet piling is shown. That was put in, in case there should be any tendency to erode the channel and undermine the structure. It was not to intercept the water; that would be the wrong place for intercepting the water.

The plan shows the triangular buttresses 14 ft. apart, and the reinforced concrete abutments; also the downstream apron of concrete blocks; the specifications require that these blocks be built in squares and be perfectly separate from each other, the idea being that in case the water should undermine these blocks, they could loosen up, settle, and still offer a protection against erosion. The specifications state:

“No vertical construction joints, lines or surfaces of demark-
“ation in the concrete masonry will be permitted,

“(a) in the main wall of the dam, *excepting* opposite the center
of the counterforts,

“(b) in the foundation floor of the dam *excepting* under the
“center of the counterforts or *excepting* in a direction parallel
“to the crest of the dam,

“(c) or between the foundation floor and the concrete sills
“under said floor or in any other part of the work where, in
“the opinion of the Engineer, construction joints or surfaces
“of demarkation between new and set concrete would weaken
“the structure. The main wall of the dam shall be built into
“the abutments without construction joints in the plane of the
“face of the abutment.”

The structure as a whole is in compression. In that respect I would perhaps criticise Mr. Jackson's type—the last type shown—where the base is in tension and has a tendency to slide on the bottom.

W. H. Finley, M.W.S.E.: I was interested in what Mr. Bainbridge said regarding the use of steel, and the possibility of corrosion, quoting Mr. Cooley's remarks from a previous paper. If I am not mistaken the bear trap dam depends today altogether on the durability of steel. Am I not correct in this, Mr. Dart?

C. R. Dart, M.W.S.E.: Yes, I think you are.

C. B. Burdick, M.W.S.E.: I believe that the general principles that Mr. Jackson has mentioned in connection with the design of his dams are important ones, and that they should be utilized to the best possible advantage wherever the circumstances will permit.

In regard to Fig. 2, "Cross section of coffer-dam for shallow water," I will say that the use of this type of structure has not been confined to coffer-dams, and has been used, quite frequently for water storage especially in situations where a hard bottom is available. If I remember correctly, there was, until recently, a dam of this type in use at Kankakee, constructed of timber. It was quite an old dam, on rock bottom. A structure of this type has one disadvantage: that all the timbers furnishing the strength of the structure are usually open to the air or only occasionally covered with water, and are therefore necessarily short-lived.

In regard to Fig. 4, "Typical cross section of earth dam," I believe the location of the puddle core in that structure is more nearly correct than the ordinary location in the center of the structure. In fact, I have thought sometimes that we might go even a little further than the method shown in the section, and place the core on the outside, utilizing it both as a core and as a pavement, which is sometimes necessary. The principal objection, however, to that procedure lies in the fact that any pavement above the water surface must be protected from the heaving of frost, which is somewhat difficult to do, with any membrane on which you are depending for watertightness.

I am a little surprised at the impression conveyed by Mr. Bainbridge, that in his opinion steel is a more durable material than masonry in the structures under discussion. There may be special cases tending to bear out that opinion. But I very much doubt that any such conclusion can be reached by the general examination of steel and masonry structures in wet places. The metal structures which have come to notice in my hydraulic work have in many cases been rapidly deteriorating by corrosion. In steel pipes it has been my experience that corrosion is very rapid, and that paint and even special protective coatings are not successful in preventing rapid deterioration. Of course there are all kinds of masonry, and some of it is short-lived, but I am of the opinion that first class masonry will be much longer lived than steel can possibly be.

Mr. Finley: I am glad to note that Mr. Burdick agrees that the proper way to build an earthen dam is as shown in Fig. 4. He seems to think that it is better than the older method of putting the core wall in the center, although that method of building a dam is still being used. Take the dam at Belle Fourche, South Dakota, now nearing completion, which is being built for irrigation purposes. It is the largest dam in the country and is built with a puddle wall in the center. It is built of the gumbo material found in that part of the country. Briefly, their method of building is

to spread that material in 6 in. layers, wet it and roll it; then, on the upstream face they shave off 9 in. of the surface, so they get back into the compact material; then they line that face with concrete, first covering the face with gravel to 2 in. I have always questioned building a dam with the core wall in the center.

I have one objection to what Mr. Burdick said in regard to the base; trouble may arise, not only from frost but also if you use ordinary clay it is liable, when the water is low, to crack. Some years ago I had something to do with some small dams in southern Illinois, built of ordinary material found in the bottom of the stream, mostly silt. The spillway was built in the middle of the dams, with the result that the dams went out. Another dam of larger dimensions was built, practically as shown in Fig. 4, and is giving very good satisfaction. I believe the dam should be sealed off as near to the water surface as possible, and not give any chance to the section of the dam being saturated as you have in the dam with puddle core or masonry core.

I would ask Mr. Jackson how the beaver under-drains his dam?

Mr. Jackson: The cross section of the beaver dam is concave up-stream. The down-stream of the dam stands at an angle of about 45 degrees. The dam is made up of loose twigs and limbs; then he curves the dam up-stream; he interlaces twigs and limbs, and then plasters the structure all over on the water-side with mud. There is always a certain amount of water going through the dam,—enough to keep it moist. The general idea is that the water-tightness is on the upper side, and the lower part is an open mass of twigs and limbs. I made a careful examination of one that was about 7 ft. in height, and discovered that the beaver was ahead of me several thousand years in this matter of employing hydrostatic pressure to the greatest advantage.

Mr. Bainridge: I differ with some of these experts on the question of building earth dams. Probably 99 out of 100 are built with the puddle core in the middle, and I think that is the right place for it. The idea is to provide earth enough back of the puddle core to stand the pressure of the water. The earth in front of the puddle core does nothing more than to hold up the puddle wall; that is all it is intended for, and with the vertical pressure on the puddle wall, there is less chance of its sliding or breaking than if it is inclined horizontally or if it is near the face of the dam. If it is near the center of the mass of earth, it is better protected than it would be in any other position, and less liable to slide.

Mr. Burdick: One matter that might be spoken of, in regard to this core wall, in the construction of dams, is that the designs change as the character of materials used in construction change. When dam material was limited to earth and timbers, builders perhaps made the best use of principles that they could, in using those materials. At the present time we have more materials at our

disposal; we have steel, which is comparatively recent in its availability for this purpose; and also reinforced concrete. With the old non-reinforced masonry core walls I think the center location, or at least such position as would permit of a vertical or nearly vertical wall is justified. Now we have materials which are better adapted to an inclined position than the old, heavy, non-reinforced masonry walls, or walls of clay puddle. The inclined wall or skin upon the face of the dam was first used a few years ago in the construction of rock fill dams, where water-tightness was obtained by a thin shell of timber or steel plates. These materials are susceptible of considerable settlement without serious damage.

I. F. Stern, M.W.S.E.: This question of the sliding of the retaining wall on the earth has come up with our company again and again. Mr. Finley made a suggestion, that we carried out which seemed to work very well, to let the lower surface of the foundation or the footing for the retaining wall have an inclination. That is, let the footing on the back be, say, three feet deep, and at the front, where you come out into the street, have that two feet deep; this would mean that to have any sliding you would have to raise the whole retaining wall. Has that principle ever been used in dams?

Mr. Jackson: As a matter of fact, we do practically the thing you speak of, where we found a dam on a gravel bottom. It is a very good principle.

Mr. Burdick: I would ask for an explanation of the corrosion of iron pipe in the ground.

Mr. Bainbridge: That it is due to electric currents, there is no question. It occurs in cities. Place an iron pipe in the ground, in some place where there is no possibility of its being affected by an electric current, and it will not corrode. But in cities, where the pipe comes in contact with electric current, in the earth it goes to pieces.

CLOSURE.

Mr. Jackson: I must say that these unorthodox ideas of mine have been received very kindly; I rather expected there would be more severe criticism.

Referring to Mr. Bainbridge's remark about the stability of masonry dams. In the paper it will be noticed that I recognize that there is a certain amount of stability of dams which is not calculable. Of course there are other elements of stability that must be counted on to make the dam safe, but they are not calculable, and have never been included in the formula.

The matter of draining in a masonry dam is extremely important as well as in this dam.

In regard to the relative cost of steel dams, I think I am perfectly right in saying this: Take any dam of about 50 ft. or more in height, and for given factors of safety of 4 or 5 for the strength of material of the steel dam, and with a factor of safety against

sliding of 2 or more, and you can get the structure in steel very much cheaper than in any other possible material. If you undertake to build a masonry dam a factor of safety greater than 2 against overturning, or 1 against sliding, and include hydrostatic uplift, you will almost double the amount of masonry required. In any of these dams where you secure water-tightness by means of steel or concrete, the only thing you want to have is simply one continuous concave water-tight surface properly sealed to the bed of the stream, then the question of hydrostatic uplift does not enter into the matter, and you can get any factors of safety you want.

As far as durability of steel under water is concerned, it is only the water-tight surface, the one surface of the steel that is not open to inspection and constant care. The under side of the plates is as dry as any other. It is painted every once in a while and rain cannot strike it. Of course we cannot examine the water face of the plate, but, as explained by Mr. Bainbridge, under fresh water metal does not deteriorate rapidly if at all.

As far as the lower part of the steel plates are concerned, of course we put in a back fill. Suppose you put a layer of earth over them; you then have perfect means for preventing the corrosion of the metal. One can go further than that and cover the inside of such a structure with a reservoir lining. The principle of using a curved surface on the water side of the dam tends to take advantage of the hydrostatic pressure to the utmost in order to secure stability against sliding and overturning.

This is probably the first written recognition of this principle, which I believe will eventually greatly influence the designs of dams, particularly those of steel and reinforced concrete.

My thanks are due to those who have taken part in the discussion.

PHASES IN THE DEVELOPMENT OF THE STREET RAILWAYS OF CHICAGO

BION J. ARNOLD, H. B. FLEMING AND GEORGE WESTON.

MEMBERS W. S. E.

Presented at a Joint Meeting of the Electric Section, W.S.E. and of the Chicago Branch, A.I.E.E.—May 28, 1909.

Mr. W. L. Abbott, M.W.S.E. (Chairman): We are indeed to be congratulated in having been able to make arrangements for the program which we have tonight. The traction problem of Chicago has been one of paramount interest here for years, and it was not until comparatively recently that this community was able to free itself of entanglements so that it could go about the reconstruction of the street railway systems. Having so cleared itself, it determined to have the best traction systems which it is possible to construct. The city, with the traction companies, proceeded to organize a Board, to take up and solve these questions as they should be solved, and then reconstruct the traction systems according to the plans which they had designed.

It is our privilege to listen to these engineers who have this work in charge, engineers whom we all know are the peers of any in the country in this line of work. The Board of Supervising Engineers is presided over by a gentleman who is a Past President of the Western Society of Engineers, and also a Past President of the American Institute of Electrical Engineers, and being the Chief Engineer of the Board it is very appropriate that he should speak here tonight and open this discussion.

I have great pleasure in introducing Mr. Bion J. Arnold, Chairman and Chief Engineer of the Board of Supervising Engineers, Chicago Traction.

Mr. Bion J. Arnold, M.W.S.E.: My mission tonight, as I take it, is to outline in a general way the steps which led up to the adoption of the present ordinances and to give a general statement of the way in which the work of the Board of Supervising Engineers is conducted, leaving to other members of the board to follow and explain to you more explicitly what we are really doing.

Perhaps, while you may have read in the past about our traction problem and do read in the papers regarding traction at the present time, you may not have read the papers during the formative period of this traction question or prior to the time when the present ordinances began to be discussed, so that it may be well to go back a little into the history of the traction situation prior to the adoption of the present ordinances. This traction question had been a question in this city for about ten years prior to the adoption of the present ordinances on February 11, 1907. During these preceding ten years, various differences of opinion arose between the citizens and the traction companies, as is often the case in other cities. Most of these differences arose through misunderstandings, and it was

only when they were thoroughly discussed—threshed out, as it were, before the public and before the authorities representing the city—that they were finally understood and a basis agreed upon which forms the present plan under which we are now reconstructing the properties. These ordinances were shaped only after many months, I might say years, of work on the part of the legislators of the city and of engineers representing the city, in determining the value of the present properties and in assisting in outlining the present ordinances. As a step precedent to the establishment of the present ordinances, it was deemed by the authorities of the city necessary to value the properties of the present street railway companies, and a valuation commission was organized in 1906 to value the properties. This was called the Traction Valuation Commission, and consisted of three men appointed by the city. These men spent several months examining the properties, and finally submitted to the City Council a report which fixed the valuation of the properties at about \$47,000,000, exclusive of the pavement, or about \$52,000,000 including the pavement. The reason that the valuation was given in this manner was due to the fact that there was a legal question involved, which could not be determined without litigation. The attorneys for the railway companies contended that they were entitled to credit for the pavement, while the attorneys for the city contended that the companies were not entitled to credit for this pavement. There was no way for the Valuation Commission to determine this question; consequently it submitted its figures both ways, in order that the City Council, through its Transportation Committee, could determine which figure it wanted to take or whether to make an average of these figures, which was finally done. The result was that the Transportation Committee of the City Council finally agreed upon an even figure of \$50,000,000 as a fair valuation for the property of the two railway companies—the Chicago City Railway Company and the then Chicago Union Traction Company, now the Chicago Railways Company. Of this sum, \$21,000,000 was allotted to the Chicago City Railway Company, and \$29,000,000 to the Chicago Railways Company, and those figures were accepted by the railways and formed the nucleus of the present valuation of the properties.

The ordinances provide that the properties shall be reconstructed under the direction of a Board of Supervising Engineers, and in accordance with plans prepared and approved by that Board. The companies are to be credited with this \$50,000,000 and with all additional money that is put into the properties in accordance with the plans which must meet with the approval of the Board. Thus the city, in case it ever should get ready to purchase, knows the exact price of the properties at the time of the purchase, as no money is credited to capital account without it is certified to by the Board, the certificates being filed monthly with the City Comptroller. There is thus always a record in the City Hall of the exact

amount of money that has gone into the properties ; the work of this Board, among other things, is to certify, from month to month, the amount of work done during the previous month.

These ordinances provide in general as follows: the railway companies agree to completely rehabilitate the properties and to furnish sufficient money to accomplish this purpose in accordance with the plans which this Board prepares, there being no limit to the amount of money that the railway companies are required to furnish, leaving that question to the judgment of the Board of Engineers.

This Board of Engineers consist of four men, two of whom represent the companies, one represents the city, and the fourth man represents both parties. When any question arises which affects one company, that company has a full vote through its representative on the Board, the city has one full vote, and the third man has the deciding vote between the two, in case of a difference of opinion. I am glad to say that up to the present time there have been very few final differences, almost all questions having been decided by a practically unanimous vote. In case a question arises which involves the interests of *both* the railway companies, then the representatives of the railway companies upon the Board have a half vote each. So that there is always one railway vote, one city vote, and one independent vote. It may be cast with the railway company or it may be cast with the city ; it depends upon what this third man on the Board thinks of the question. I want to make it clear, because the Board practically consists of three men, when it affects the interests of any particular company, but when the two interests are affected, then there are four men that vote, but the two railroad men then constitute one vote. That plan was provided for in the ordinance in order that there might always be an odd vote on the Board.

Under the ordinances, the companies are required to largely reconstruct their systems within a certain three years "rehabilitation period." This rehabilitation of the properties has cost close to \$30,000,000 in the last two years. We have the remainder of this season for work with the Chicago City Railway Company, during which it will spend probably \$2,000,000. The Chicago Railways Company has yet two years for its improvements so that there will probably be put into the properties, before we get through, somewhere between \$35,000,000 and \$40,000,000. We hope to get through within the latter figure, but we are not sure, as it depends upon whether we build power houses or not.

The ordinances provide that the railway companies shall receive a profit on this reconstruction work of 10% over and above the actual cost to the company. In addition thereto, there is an additional 5% allowed for securing the money, that being the ordinary brokerage that it costs to secure money, taking into consideration the discount on the bonds and other incidental expenses toward se-

curing it. So that the companies receive 15% over and above the actual cash used in the rehabilitation work, their net profit being 10%. They are furthermore required to set aside or spend upon the properties after they are once reconstructed, 6% of the gross receipts for maintenance or repairs. That means ordinary up-keep, such as replacing small parts, brake shoes, wheels, and things of that character. In addition to that, they are required to set aside 8% of the gross receipts monthly, into a special fund, deposited in banks designated by the city, and approved by the Board, which funds remains in the bank unless it be drawn upon to replace principal parts of the property. For instance, if it becomes necessary to replace an old car with a new car, this fund is drawn upon for an amount equivalent to the value of the old car and the difference between the cost of the new car and the cost of the old car is charged to capital account. The old car is sold; the amount of salvage from the old car is deducted from capital account. Thus capital account is only increased to the extent of the cost of the new car over the old car, less the salvage on the old car. That is why this fund is called the renewal and depreciation fund. The ordinances were framed upon the theory that the city should be able to purchase the properties at any time, upon giving six months' notice to the railway companies of its desire to do so. That is, the city can purchase on the first of February of any year, after having previously given six months' notice of its desire to purchase. The price that the city would have to pay would be known by virtue of the valuation previously fixed, viz., \$50,000,000, plus the sum of the certificates issued by the Board up to the time of purchase. Now in order that the city would be insured of a first class railroad system, or enough cash somewhere to put it in first class shape, this renewal fund was established. After the rehabilitation work is completed, it is expected that the railway will be maintained to as high a point of efficiency and maintenance as a railroad can be maintained. We have assumed, from the best information that we could gather, from the experience of the members of the Board, and from other engineers with whom we have conferred, that it would be possible to maintain a railroad at about 85% of its first cost. Before any large railroad system is finished, part of it is worn out, consequently you can not maintain it at 100% of its original cost, but you can probably maintain it at about 85%, and this renewal fund is intended to maintain the property up to that point all the time, and that 85% is considered under the ordinance as 100% good, that being the highest point at which it is expected that you can ever maintain this property. But suppose at the time of purchase by the city that the railroad companies have not maintained the properties up to this 85%, then the difference between that value and the value at which they have maintained it, will be found in cash in this fund, which will be taken over by the city at the time of the purchase. Thus the city acquires a railroad in first class

condition, or it acquires a railroad in poor condition but with enough cash on hand to put it in first class condition. This is a very wise provision in the ordinance, although there has been no disposition shown as yet, not to put the money into the roads and maintain them properly, and probably will not be.

The ordinances provide that out of the gross receipts of the railway companies, first shall come the operating expenses of the companies; then will come this renewal fund of 8 %; the operating expenses including the 6% fund previously mentioned. After the operating expenses and these funds have been provided for, the companies receive 5% upon the amount of cash invested in the properties at the time of consideration, as evidenced by the Board's certification. After this 5% has been deducted, there remains a net balance of *something*. That net balance is divided between the companies and the city in the proportion of 55% to the city and 45% to the companies. This feature of the ordinances naturally requires some supervision on the part of the city or somebody, in order that the public may be assured that the city is receiving its proper proportion of the net profits. Consequently, the power of supervision of the books of the companies is placed with this Board of Supervising Engineers. The result is that the Board has a large auditing staff, which is constantly in touch with the books of the company; in fact it has auditors in the offices of each of the companies, supervising the books, or, to see that the books are kept in accordance with the forms which have been originated by the Board and approved by the City Comptroller. Our auditors pass from one company to the other and check up monthly all expenditures upon which to base our certificates. During the reconstruction period, these certificates are not only based upon the books of the company but also upon the reports of the Assistant Engineers, working under the Chief Engineer of the work, of which Mr. Weston will tell you later, as he is the Assistant Chief Engineer and has charge of that part of the work. The Assistant Engineers are inspecting the work all over, simultaneously with the auditors' examination of the companies' books. Each set of men send reports into the office and the heads of the departments make up their reports to a certain point, independently of each other. Then the reports are compared and if there is no discrepancy between the engineers' report and the auditors' report, they are assumed to be correct, but if there is a discrepancy, then the thing is analyzed carefully and made to harmonize before the certificate is finally passed by the Board and submitted to the City Comptroller. Thus you see we have two independent sources of assuring ourselves of accuracy: first, the auditing department; second, the engineering department; and we feel that the work is thoroughly and carefully done, and that it is accurate, though of course some minor mistakes may creep in from time to time. But there is always a chance for correction, as we have sixty days to correct any certificate given. The

result is we catch the error, if any, and correct it in a correcting certificate, and we believe that the records of the Board will be found sound by any one up to the present time, and we hope they will so continue.

Chairman Abbott: Those people who live in that part of Chicago which they are pleased to call the residence part of the city, the South Side, have always attributed not a little of the advantages of their section of the city to the superb street car service which has always been furnished them. When the cable was finally hauled out of the trench on its last round and everything was replaced by electric cars, the system which had theretofore been satisfactory became even more so. Mr. Harry B. Fleming, who has had responsible charge of the work of directing the engineering of the City Railway and who is also a member of the Board of Supervising Engineers, will next address you.

Mr. H. B. Fleming, M.W.S.E.: When requested to talk informally on certain phases in the development of the street railway systems of this city, I hesitated to accept the invitation, owing to the fact that the work covered such a broad field that it was difficult to decide on a subject which could be covered in the short space of time allowed and in a manner to prove of interest.

After consideration, I have selected the subject of

STREET RAILWAY CARHOUSE DESIGN AND OPERATION,

and I can only hope at the present time to call your attention to certain phases of this subject which are new and which I think will be of interest.

LOCATION: In selecting a location for a carhouse, the points to be considered are:

1. Provision for future requirements.
2. Convenience and economy of operation, i. e.—minimizing of dead mileage and maintenance.
3. Fire Risk—location with reference to other buildings.
4. Economy of Construction.
5. Facilities for drainage and sewerage, especially if pits are used.
6. Room for proper layout of tracks and extensions.

DESIGN: The Board of Supervising Engineers in considering the question of Carhouse design reached the following conclusions:

1. All carhouses that were to be permanent should be divided into bays or sections so as to reduce to a minimum the loss, in case of fire.
2. New carhouses to be built should also be divided into bays or sections and should be of fire-proof construction.
3. Where any old carhouses are to be remodeled in such a manner as to become a permanent structure involving the expenditure of considerable money, such buildings should be fire-proof.

4. Where it is necessary to remodel old carhouses, in order to accommodate the large modern cars temporarily and which would probably be abandoned in the near future; such modifications should be made with as little expense as would make them reasonably safe for the storage of property contained in them and that they should be abandoned and new fire-proof carhouses built in their place, at the proper time, at the same or more desirable locations.

5. Wherever conditions will permit, the carhouses are to be of the double-ended type.

The latest approved design of carhouses conforms with the above general requirements and I wish to call your attention to various features in connection with the same.

ACCOMMODATIONS FOR TRAINMEN AND CARHOUSE EMPLOYEES: Ample accommodations have been provided for the office of the Division Superintendents, Clerks and Trainmen; in addition, a Club Room, Coat Room and Reading Room is furnished for the use of the employes assigned to duty at the Division of which the carhouse in question is the headquarters. The club room is furnished with pool and billiard tables, chess and card tables and a small amount of gymnasium apparatus and a stage. These rooms are open to employes at all times and they are given the privilege of holding various entertainments in them. A small library is kept in sectional book cases along the walls of the reading room and on the tables are current issues of daily papers and some of the technical journals.

Special attention has been paid to providing toilet facilities for all of the carhouse employes and in addition the repairmen are provided with locker rooms and lunch rooms.

CAR STORAGE SECTIONS: Each bay or section is independent of all others and all openings between sections are provided with double automatic steel fire doors. Each bay is approximately 490 ft. long and 38 ft. wide and contain three (3) tracks, with a capacity of thirty (30) standard double truck cars.

Each track is divided into three (3) sections; the middle section being pitted, so as to permit of ready inspection and repair of the trucks, motors and car equipment suspended underneath the body.

The fire-walls of each bay are of brick, 12 in. thick, spanned by re-inforced concrete girders spaced 16 ft. centers and 18 ft. in the clear and covered with a re-inforced concrete slab 4½ in. thick, cast in one piece over the entire roof. The middle eight ft. section of the roof of each bay, except at the end panels, is covered with fire-proof sky lights for lighting and ventilation. The ends of each bay are provided with galvanized steel rolling doors.

The tracks in the bays are connected with the main line in the street by curves at each end, or in other words the carhouse is of the double ended type, so that the cars can come in at one end, be

washed and fumigated, passed over the pits, inspected and repaired, and thence moved on to the other end of the carhouse ready to go in service again, without any switching or reverse movement after the process is once started.

REPAIR SECTION: Every carhouse is provided with one section which is known as the *repair section*, where special provisions have been made and special machinery installed for the economical handling and repairing of cars.

I desire to call your attention, at this time, to the overhead travelling cranes, by the use of which we are enabled to shift our standard double truck car bodies from one pair of trucks to another pair in less than three minutes. These cranes are also very useful in the truck repair section. In addition to the above, each repair section is provided with the following tools:

- 1 motor driven lathe.
- 1 motor driven drill.
- 1 motor driven emery stone with 48 in. grindstone.
- 1 portable beam for swinging armatures into lathe with triplex chain blocks.
- Assortment of drills, and of wrenches.
- 1 mandrel and 40 in. forge.
- 2 vises.
- 1 carpenter bench.
- 1 pipe-fitter's bench.
- 1 6-foot face plate, assortment of sledge-hammers and hand hammers, cutting chisels, drifts and jacks.

It should be understood, that only certain classes of work are handled in the carhouses. Whenever cars require general overhauling or repairing, they are sent to the main shops.

LIGHTING AND WIRING: All light and power wires are installed in conduits and according to the requirements of the National Board of Fire Underwriters. The general lighting is accomplished by means of arc lamps, five in series, on 500 volt circuit. The lights are staggered in various bays so as to provide general lighting between the rows of cars. Lighting in the pits is obtained by the use of incandescent lamps on 500 volt circuit, special arrangements having been made for pit lighting, in order to reduce the same to a minimum and yet provide the lights needed by the inspectors and repairmen.

The power supply for the building is controlled from what is known as the switch room. The power supply for each bay and the trolley wire leading from the same to the street is also controlled from this switch room so that in case of fire in any one section, the power can be cut off from the same without interfering with the supply in the other sections, which would prevent the removal of cars from the danger zone.

treet, so that it
ough a burning

adiation and in
t installed. In
o provide over-
nce has proven
oils only in the
the end doors.
are of the re-

provided with

, such as storm

pplies required

ve, special at-
y fire and the
will note from

3.

o Rate \$1.00

o Rate .82

o Rate .68

o Rate .60

o Rate .50

nium \$7,150.00

er the principal
ning work, to-
sing the same,
who so desire
iefly they con-

“D.”

G.”

This switch room has direct connection with the street, so that it would not be necessary for the operator to go through a burning section to pull the desired switch.

HEATING: The buildings are heated by direct radiation and in most of the buildings the vacuum system has been installed. In the original installation it was considered necessary to provide overhead coils in the vicinity of the sky lights, but experience has proven that the bays can be properly heated by locating the coils only in the pits and on the sidewalls in the immediate vicinity of the end doors.

The stacks in connection with the heating plants are of the reinforced concrete type.

UTILITY SECTIONS: Each division carhouse is provided with quarters for the following utilities:

1. Wreck and trouble wagons.
2. Track dept. section house and tool room.
3. Dry sand storage.
4. Salt storage.
5. Storage of summer and winter equipment, such as storm windows, screens, etc.
6. Stock room, containing material and supplies required for the carhouse maintenance work.
7. Advertising room.

INSURANCE: In the design briefly described above, special attention has been given to protection against loss by fire and the results obtained have been very satisfactory, as you will note from the following:

Comparison Statement—Fire Insurance.

Total Ins., 1906, \$6,441,869.00	Premium \$64,418.60	Rate \$1.00
Total Ins., 1906, 7,432,413.00	Premium 61,024.40	Rate .82
Total Ins., 1907, 9,660,000.00	Premium 65,688.00	Rate .68
Total Ins., 1908, 9,775,000.00	Premium 58,650.00	Rate .60
Total Ins., 1909, 10,300,000.00	Premium 51,500.00	Rate .50
Increased Ins., 1909, \$525,000.00	Decreased Premium \$7,150.00	

OPERATING METHODS: I have attached to this paper the principal blanks which are used in the carhouse repair and cleaning work, together with an outline describing the manner of using the same, which I will leave with the Secretary, so that any who so desire may have the privilege of examining the same. Briefly they consist of the following:

- Motorman's Sign-In-Sheet, Exhibit "A."
- Daily Record of Repairs, Exhibit "B."
- Report of Cars Sent to Shop, Exhibit "C."
- Report of Cars Returned to Service, Exhibit "D."
- Repairman's Slip, Exhibit "E."
- Car Placer's Record, Exhibit "F."
- Daily Report of Carhouse Foreman, Exhibit "G."
- Car Cleaner's Report, Exhibit "H."

CARHOUSE REPAIRS AND CLEANING.

Blanks and Forms as used on the Line of the Chicago City Railway Company.

Motorman's Sign-In-Sheet, Exhibit A.

Motormen are required to make a record of the condition of every car they operate. This applies equally to supply and work cars, as well as passenger cars.

Pads of these sheets are kept in trainmen's waiting room in a neat frame. Motormen state the time car is turned in, car number, condition of car, writes nature of defect, or O. K., and signs his full name.

After one of these sheets is filled out clerk to carhouse foreman takes it and enters on Exhibit "B," explained next; the report is then filled in by carhouse foreman in column showing "Action Taken." He here states "Repaired," "Held In," or "Sent to Shops."

After foreman finishes with sheet, showing action taken on every car reported, it is turned into office of Assistant Master Mechanic, who certifies to the correctness of the record.

At the end of each month the records from each carhouse are sent to the Claims Department for permanent file.

Daily Record of Repairs, Exhibit B.

This record is kept in carhouse, easily accessible to repairmen. Cars reported defective on Sign-In-Sheet are listed on this record. Down the left hand side are listed in alphabetical order, the parts of a car most frequently requiring attention. Car number is placed in proper column, and next to this column is a space in which the repairman places his pay roll number, after he had made the necessary repairs. This gives a record that the defects reported by trainmen have been repaired. Carhouse foremen can tell at a glance who the individual was that made the repairs.

The repair work is automatically distributed to the repairmen and a complete record of each day's repair work is kept on file in carhouse foreman's office.

Report of Cars Sent to Shop, Exhibit C.

Whenever necessary to send a car to the shops, one of these forms is filled out by carhouse foreman and accompanies the car to the shops. After repairs are made, shop inspector certifies on back of this record that he has inspected the car and same is in good condition, before it is sent back to carhouse.

In case of repairs caused by accidents in service, the expense of repairs is entered on back of slip.

Report of Cars Returned to Service, Exhibit D.

In case repairs could not be made on the same date as reported and it becomes necessary to hold the car in for one or more days, the carhouse foreman fills out one of these blanks for each car re-

ported on Sign-In-Sheet as "Held In"; when he returns car to service he certifies to repairs having been made and this is sent with the Sign-In-Sheets to the Claims Department for permanent file.

Repairman's Slip, Exhibit E.

In order to further check the individual work of each repairman, he is furnished with these blanks, and his work, as taken from the larger record sheet, is entered on blank which shows the complete record of each man's work per day. This not only assists in Claims work in showing that car was repaired, but gives the foreman opportunity to trace back poor work to the individual.

Car Placer's Record, Exhibit F.

As cars are turned in by trainmen they are met by car placers who line up the cars in their respective bays (certain cars always being kept in a given bay).

Car placer enters on these sheets car numbers in the order that they are turned in. This gives permanent record of location of each car in the carhouse. On back of these reports car placer notes defects reported verbally by motorman when he turns car in. With this verbal report, the Sign-In-Sheets, and daily inspection made regardless of any reported trouble, it is seldom that a car is put into service in any way defective.

Daily Report of Carhouse Foreman, Exhibit G.

A daily report is made by each carhouse foreman to the Assistant Master Mechanic, showing statement of cars charged to that division, defective cars "Pulled In" and cars "Held In" for repairs.

The per cent of the "Pulled in" cars to cars operated is figured and noted on each day's report. These per cents are plotted on cross section paper Exhibit "H." Lines showing daily records of each car house are carried across the chart in color, each division having its indicating color.

These charts are drawn up to show two months' continuous operation. The weather condition is noted on the chart each day. This affords the individual responsible for the maintenance work a comparison of the character of the work at each division and by analyzing a peak on the chart by means of daily report showing what is causing the "pulls in" he can quickly tell what is causing the trouble on each division.

Car Cleaning.

Car cleaning, inspection, and repairing are arranged to be carried on progressively as the car is moved up from rear of carhouse, over inspection pits to storage tracks in front; cars are first met by cleaners who sweep floors and platforms.

All cars are swept each time they are turned in from service, but body cleaning (with exception of emulsion cleaning) is done when car is finally turned in at night.

Car Cleaner's Report, Exhibit H.

Each cleaner is required to fill out this blank showing total number of cars worked on and the class of cleaning he is required to do; from these individual slips a permanent record is maintained in a car cleaning book which shows the class and amount of cleaning work done on a car each month. This record is kept by the use of a set of symbols (see Exhibit "I") certain marks indicating a class of cleaning or inspection, or disinfecting.

Cars are cleaned with emulsion cleaner at intervals of about forty days and this cleaning is entered in record book in red pencil. By this means it is easy to tell which car is next in order for thorough cleaning with the emulsion process.

Terminal Cleaning and Repairs.

At the terminus of each line are men known as "Terminal Cleaners." These men are furnished with full supply of small repair parts, and are expected to make minor repairs, thus keeping in service many cars which otherwise would have been "pulled in." Also, each car is swept at the end of each round trip, thus keeping the floors and platforms always in a clean condition.

Chairman Abbott: I had hoped at this point in the program to have the pleasure of introducing to you Mr. John Z. Murphy, Chief Engineer of the Chicago Railways Company, but he is not able to be with us this evening. I can not, however, forego the opportunity to pay a tribute to the rare accomplishment of this engineer. Mr. Murphy's early experience and training as a marine engineer and as a sailing master taught him the useful lesson that, regardless of what sort of a craft he found himself afloat in, it was expedient to keep the craft afloat and bring it into port again. The necessities which his later position put upon him showed the value of his early training. Placed in charge of a traction system which was composed of overlapping and underlying systems of various sorts, and which was skilfully bound hand and foot by one of the ablest "financiers" of the country, Mr. Murphy with scarcely any visible means of support, I was going to say, to carry on his department, rebuilt his engines, rewound his generators, reconstructed his lines, rebuilt his motors, and kept going in fairly good, serviceable condition, a system which many would have been disposed to have shut down and called for a receiver to sell out. But Mr. Murphy, with his persistence, with his ingenuity, and his great energy, was able to keep the North and West Side systems going in a condition which furnished fairly good service to those two sections. We very much regret Mr. Murphy's inability to be here this evening.

Some twenty years ago it was my pleasure to have the next speaker of the evening check up my work and allow the estimates on it. I have been grateful to him ever since, for passing almost everything I turned in. Mr. Weston has grown up with the traction system of the city. He built the cable systems of the North and West Sides, and later on it was his privilege to see the mistakes

of his earlier work and rip it out, and install electric systems instead.

It is my pleasure to introduce Mr. George Weston, Assistant Chief Engineer and representative of the City of Chicago on the Board of Supervising Engineers.

Mr. George Weston, M.W.S.E.: In response to your Chairman's request to address you this evening on matters pertaining to the workings of the Board of Supervising Engineers, I have prepared brief outlines of the ordinance requirements for rehabilitation of the properties and of the organization of the work, under the Chief Engineer, of supervising and inspecting this work. This is such a large field that it is impossible to cover each division in very much detail.

The Traction Ordinances of February 11th, 1907, authorized respectively the Chicago City Railway Company and the Chicago Railways Company to construct, maintain and operate, systems of street railways in the streets and public ways of the City of Chicago, and these Ordinances also created the Board of Supervising Engineers for the purpose of administering the said Ordinances.

The Companies agreed to proceed at once to rehabilitate and re-equip their entire street railway systems and put them in first class condition as outlined in Exhibits B of the Ordinances, and in accordance with specifications prepared by the Chief Engineer of the work and approved by the Board of Supervising Engineers, and to conduct the work under the supervision of the Board.

The Ordinances provide that, if so requested by the City Council, the Companies will construct and equip extensions, not to exceed six miles of double track or twelve miles of single track for the Chicago Railway Company, and four miles of double track or eight miles of single track for the Chicago City Railway Company in each year after the three year rehabilitation period.

The Ordinances provide that, under certain conditions, the Companies are obliged to contribute an amount not exceeding \$5,000,000 to the cost of construction of a downtown subway.

The Chicago Railways Company agreed to lower and reconstruct the tunnels under the Chicago River at Washington Street, and La Salle Street.

Certain specific service regulations are set forth in the Ordinances and the right is reserved to the City to secure adequate and sufficient transportation accommodations for the people, subject to the Board of Supervising Engineers as to the reasonableness thereof.

The Ordinances also provide for a modern type of double track passenger cars to be purchased by the Companies in the future, and stipulates that within three years from the respective acceptances of the Ordinances the Chicago City Railway Company must have in operation on its lines at least eight hundred cars of this modern type to be approved by the Board of Supervising Engineers; and the Chicago Railways Company must have in operation on its lines at least twelve hundred such cars.

Provisions are made for the use of a modern type of track rail with a thorough bonding of the rails at the joints.

The Ordinances further provide that all feeder and transmission wires shall be laid underground within that portion of the City bounded as follows:

“Beginning at Lawrence Avenue and Lake Michigan, west
“on the North side of Lawrence Avenue to Clark Street.

“Southwest on the West side of Clark Street to Southport
“Avenue.

“South on the West side of Southport Avenue to Belmont
“Avenue.

“West on the North side of Belmont Avenue to Western Ave-
“nue.

“South on the West side of Western Avenue to 22nd Street.

“East on the South side of 22nd Street to Halsted Street.

“South on the West side of Halsted Street to 39th Street.

“East on the South side of 39th Street to the East side of the
“right-of-way of the Lake Shore & Michigan Southern Rail-
“road.

“And South and East along the right-of-way of the Lake
“Shore and Michigan Southern Railroad to the southern most
“point of the tracks of the Chicago City Railway Company.

“Thence to Lake Michigan.

“And along the shore of Lake Michigan to the place of be-
“ginning at Lawrence Avenue.”

This comprises an area of about forty square miles, requiring an installation of approximately six and one-half million duct feet of underground conduit.

The Ordinances also provide that the Companies shall build such power-houses, sub-stations, and other buildings, together with the necessary machinery and appurtenances as may be determined upon by the said Companies with the approval of the Board of Supervising Engineers to supply whatever electric power may be required.

The Ordinances also provide for the operation of twenty-one “Through Routes,” designating the beginning and ending of the routes and the streets over which they shall be operated.

The books and accounts of the Companies are provided by the Ordinances, to be kept in such form as may be prescribed by the Board of Supervising Engineers, subject to the approval of the City Comptroller.

It will be seen by the above brief outline of the Ordinances that the Board of Supervising Engineers have been charged with a grave responsibility, and the Chief Engineer of the work with a task of most stupendous proportions in organizing the working force, directing the work of preparing plans and specifications, inspection of the work in the field, checking the accounts of the Companies, etc.

Owing to the magnitude of the work to be undertaken, the working force was organized into Divisions, and each Division placed in charge of a Division Engineer, who had specialized in the particular work included in his division.

The Divisions so determined are as follows:

Division D. Track and Roadway.

Division E. Electric Power Distribution.

Division G. Building and Fixtures.

Division I. Power Plant Equipment.

Division K. Cars and Car Routing.

Division P. Tunnels and Subways.

Division of Drafting—in charge of a Chief Draftsman.

Division of Accounts—in charge of a Certified Public Accountant.

The working force of the Chief Engineer's organization comprises one hundred and thirty-seven persons, consisting of Engineers, Accountants, and general office employees.

On March 30th, 1908, the City Council of the City of Chicago passed an Ordinance authorizing the Calumet & South Chicago Railway Company to construct, maintain and operate, a system of street railways in the streets and public ways of the City of Chicago.

This Ordinance was drawn upon lines similar to the Ordinances of February 11th, 1907, providing for a Board of Supervising Engineers, etc., and providing for the rehabilitation of the property, including forty miles of single track.

This company consolidated the Calumet Electric Street Railway Company and the South Chicago City Railway Company, and the respective properties of the Companies into one Company, with a total mileage of 98.44 miles of single track.

The City Council of the City of Chicago passed an Ordinance March 15th, 1909, to the Southern Street Railway Company (formerly the Chicago General Street Railway Company) drawn upon lines similar to the Ordinances of February 11th, 1907, providing among other things, supervision by the Board of Supervising Engineers, and the rebuilding of its property, including about seven miles of single track.

The Ordinances also made provisions for an Operating Agreement between the Southern Street Railway Company and the Chicago City Railway Company, whereby the Chicago City Railway Company was to conduct the work of rehabilitation, and to operate the road as a part of its own system. The Southern Street Railway Company own about 18 miles of single track.

In addition to supervising the rehabilitation and checking the accounts of the Chicago City Railway Company and the Chicago Railways Company, the above organization is looking after the work of the Calumet & South Chicago Railway Company, and the Southern Street Railway Company, the joint Companies comprising a total of 651 miles of single track, and the immediate rehabilitation of 280 miles of single track.

October, 1909

The Division of Track & Roadway was organized in May, 1907, and track construction work was commenced June 17th, 1907, on Root street between Wallace and State streets, by the Chicago City Railway Company. Three types of track have been designed and approved by the Board of Supervising Engineers, differing principally in respect to the foundation.

Type No. 1. Consisting of steel ties in concrete.

Type No. 2. Consisting of wooden ties in concrete.

Type No. 3. Consisting of wooden ties on a rolled stone foundation, with concrete between and on top of the ties, to provide a foundation for paving.

The rails, tie fastenings, paving, etc., of these different types are practically the same excepting that screw spikes are used with wooden ties, and with steel ties, a special clip to fasten the rail to the tie. One of the features of the track construction is that by the use of screw spikes on wooden ties or a removable clip on steel ties, the rails can be removed and replaced without disturbing the track foundation and without damage to the ties.

Several miles of Type No. 1 track with steel ties have been built by the Chicago City Railway Company, but the Chicago Railways Company have not used this type of track.

The tracks built to date by both Companies consist principally of Types No. 2 or No. 3, and the greatest mileage has been constructed using Type No. 2 construction, or a modification of the original Type No. 2, styled Type No. 2-A, which differs from Type No. 2 only in respect to the spacing, center to center, of ties.

The Ordinances provide that during the three year rehabilitation period the Chicago City Railway Company shall rebuild all of its cable tracks, and sixty miles of electric track, a total for that Company of ninety-five miles of single track; and the Chicago Railways Company shall rebuild all of its cable track and ninety miles of its electric track, a total for that Company of one hundred and thirty-eight miles of single track; a grand total for both Companies of two hundred and thirteen miles of single track. In addition to the above rehabilitation work, the Ordinances provide for about 65 miles of single track extensions.

The Chicago City Railway Company has completed to date about 84.7 miles, or 90% of the ordinance requirements for track reconstruction; and the Chicago Railways Company about 93 miles, or 68%.

The Chicago Railways Company had finished about 50% of their total rehabilitation and new extension requirements at the close of the year 1908, and have laid out a schedule for this year amounting to one hundred and twelve miles of single track, based upon a working schedule of thirty-six weeks; this equals an average of 3.11 miles of finished track per week. Up to this time the Company has practically averaged this schedule.

The Chicago City Railway Company have remaining but a few miles of rehabilitation track work to complete their Ordinance requirements and can easily finish during the present year.

The Calumet & South Chicago Railway Company have rebuilt but 2.5 miles to date of the 40 miles required by the Ordinance, but their schedule for the year of 1909 comprises twelve and one-half miles of single track rehabilitation work and about four miles of new extensions.

The seven miles of track rehabilitation for the Southern Street Railway Company is scheduled for building this year.

Track special work is a very important part of any street railway system, and this subject has been given careful study and consideration by Division D, the Engineers of the railway companies, and the Board of Supervising Engineers; and specifications covering the manufacture of special work have been prepared, under which all special work for the companies under the jurisdiction of the Board of Supervising Engineers is manufactured.

There has been placed to date during the rehabilitation period one hundred and thirty-two special work layouts and in addition seventy-nine crossovers by the Chicago City Railway Company and the Chicago Railways Company, a large percentage of which being our Type B construction, of which the curved frogs, crossings, switches and mates are solid manganese castings. All curves have been designed for safe operating clearances between cars of all types passing in any direction. During the past year specifications have been prepared covering the manufacture of open hearth steel rail, and all rails contracted for the current year will be manufactured under this specification.

The Division of Electric Power Distribution was organized during May and June, 1907, and the work of this division comprises the Electrical Transmission and Distribution Systems, consisting of underground conduit, underground and overhead feeders, underground and overhead transmission lines, trolley and its connections, bonds, auxiliary cables and telephone systems; and includes the testing of track joints for relative conductivity. Plans and specifications have been prepared by this division for typical underground conduit construction, which comprise three general types of construction:

Type A, square bore multiple duct.

Type B, round bore single duct installed in cable slot.

Type C, square bore single duct.

Typical construction for standard sizes of manholes have been designed, including concrete and brick construction. The manholes are principally being constructed of brick on account of this type of construction being more flexible than concrete construction, facilitating the working around other conduit lines, water pipes, gas pipes and other street obstructions. The larger number of manholes constructed are of the barrel shape, for the reason that this

form of manhole reduces the cost to some extent and leaves a wall face, which is more satisfactory for the training of cables.

In the early part of the work some multiple duct conduit was constructed, but it was later decided to make the single duct square bore construction standard for all Power Distribution work.

Specifications have been prepared for,

Single conductor, rubber insulated, lead sheathed cables.

Three conductor, paper insulated, lead sheathed cables.

Installation of lead sheathed cables and underground conduit.

Steel armored, lead sheathed, cables for submarine construction.

Triple braided weatherproof copper cables.

Hard drawn copper wire.

Single conductor, paper insulated, lead sheathed, copper cables.

Single conductor, paper insulated, lead sheathed, aluminum cables.

Single conductor, rubber insulated, lead sheathed, aluminum cables.

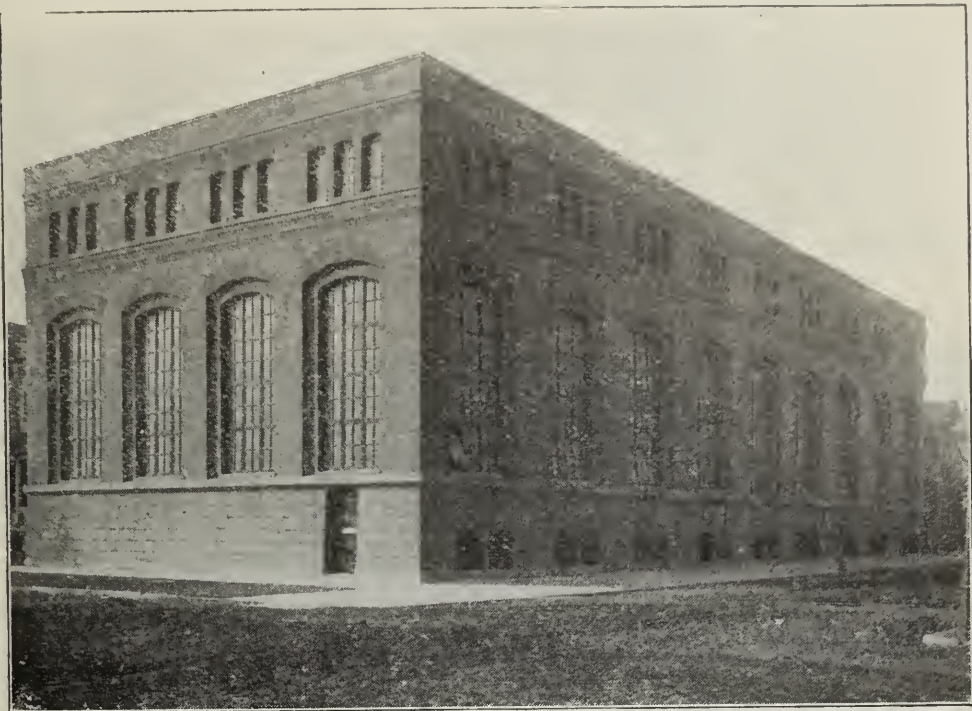
In calculating the feeders for the D. C. distribution system, the various lines of the Companies have been divided into trolley sections, and the maximum two hour schedule of cars upon each trolley section has been taken, and with this as a basis, and making a liberal allowance for average current consumption at the car (which I might say has been determined by actual observations and tests) the c.m. capacity of cable for each line has been determined, the maximum drop for heavy traffic sections being fifty volts, which has been increased somewhat on remote sections.

In figuring the negative return system, a drop of 25 volts at extreme points from the source of supply has been taken as a basis for figuring, and inasmuch as our Ordinances require that the conductivity of the rail at the joint shall be equal to the conductivity of the rail itself, and from the fact that this condition is obtained through the use of electric welded joints, full credit is given in these calculations for the carrying capacity of the track rails, and additional bare copper cable is added in order to keep the auxiliary return circuit in all locations within the specification requirement of 25 volts drop. In calculating the negative return, it is assumed that all current returns to the station from which it originates.

At all track special work layouts, each straight track rail is supplemented by a copper cable throughout the entire length of the special work, and the ends welded to the rails on each side of the special work layout.

Division G—Buildings and Fixtures—was organized in May, 1907, and took up the inspection of the construction and completion of sub-station buildings of the Chicago City Railway Company, located at 20th and Dearborn streets, 63rd street and Wentworth avenue, and 42nd and Wabash avenue, as well as two new fireproof carhouses for the Chicago City Railway Company, one located at 38th street and Cottage Grove avenue, and the other at 77th and Vincennes Road, plans for all of which buildings had been prepared by the Chicago City Railway Company and had been approved by the Chief Engineer of the Work.

In September, 1907, this division began to keep in touch with the building work of the Chicago Railways Company, and after the acceptance of its ordinance by the Chicago Railways Company,



Electrical Substation at 42nd St., and Wabash Ave.



Car barn at 69th St., and Ashland Ave.

October, 1909

January 28th, 1908, this division, in conjunction with the Engineers of the Chicago Railways Company, prepared plans and specifications for new fireproof carhouses of the double end type, and fireproof substation buildings.

Five new car houses are in course of construction by the Chicago Railways Company at this time; one located at Leavitt and Twenty-fifth streets; one at Sheffield and Wrightwood avenues; one at North Clark street and Dewey Court; one at Kedzie avenue and Van Buren street; and the fifth, at Ogden avenue and 22nd street, capable of housing 834 double truck cars; and designed as regards facilities for handling and cleaning the cars, fire protection, etc., on the general lines outlined by Mr. Fleming in his paper presented here this evening. In addition to the new car houses of the Chicago City Railway Company previously referred to, located at 38th and Cottage Grove Avenue and 77th and Vincennes Road, two additional car houses have been completed and are in operation, one located at 38th street and Archer avenue, and the other at 69th and Ashland avenue, making a total of four large modern fireproof car houses for that Company, capable of housing 1,076 large double truck cars.

Division I—Power Plant Equipment.—Steps for organizing this division were taken in the month of May, 1907, and the initial work undertaken was to inventory and value the betterments to the Power Plants and Substations of the Chicago Railway Company since the date of the original valuation, June 30th, 1906. In July daily inspection of the work in progress at every substation was commenced and daily reports made of the labor and materials used.

At the time of the organization of the Board of Supervising Engineers, the Chicago City Railway Company had in operation three steam plants, (one of which was operated only during the winter months) for the generation of electricity for operating its lines. This Company also obtained a large amount of electrical energy from the Commonwealth Edison Company through their two rotary converter substations.

Since the organization of the Board, additional substations have been built and put in operation, and a contract entered into with the Commonwealth Edison Company whereby all of the current required for the operation of the railway is purchased, and the Company receives at its substations, 25 cycle—9,000 volts—3-phase current, generated at the Fisk Street Power Plant of the Commonwealth Edison Company and delivers 600 volts to the direct current feeder system of the Road.

Five substations have been estimated as being required to supply the necessary electric current to the system of the Chicago City Railway Company when rehabilitated; a total ultimate capacity of 50,400 kw., exclusive of storage battery at Plymouth Court Substation.

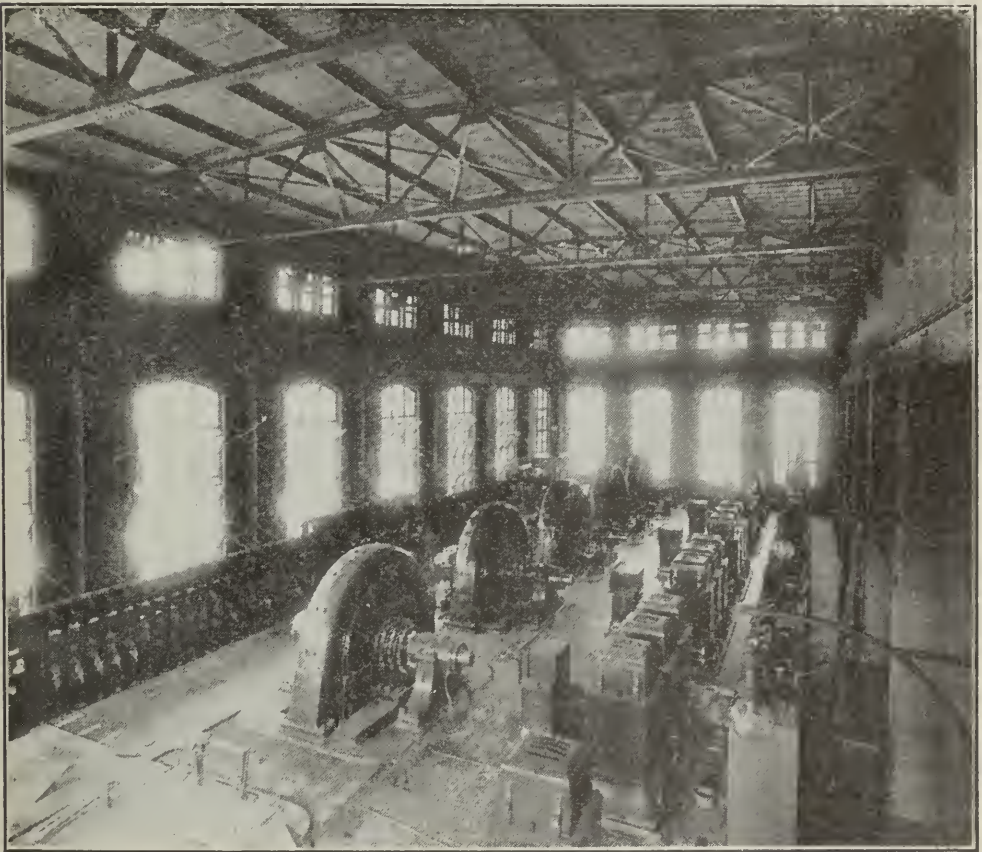
Four substations were built prior to February 1st, 1908, and con-

struction work on the fifth substation building has been commenced.

All substation buildings of this Company are designed of substantial fireproof construction, with pressed brick walls both inside and out; book tile roofs carried on structural steel trusses, of composition roof covering, concrete floors, with a red tile wearing surface, all thoroughly fireproof and architecturally first-class.

The capacities of these substations and their locations are as follows:

20th and Dearborn Streets substation: total capacity 12,000 kw. Present rotary converter equipment consists of four, 2,000 kw. units and three, 1,000 kw. units.



Interior view of Substation at 42nd St., and Wabash Ave.

63rd and Wentworth Avenue substation. When extended to its full capacity this station will accommodate 12,000 kw. There are at present three, 2,000 kw. and three, 1,000 kw. rotary converter units.

42nd and Wabash Avenue substation; total capacity of substation 14,000 kw. There are at present five, 2,000 kw. rotary converter units in this station.

48th and Honore Street substation. Total capacity of this sub-

station 10,000 kw. There is being installed at present three, 2,000 kw. rotary converter units.

Plymouth Court Substation. This substation is one of the Commonwealth Edison Company's buildings in which the Chicago City Railway Company have been given space for the placing of two 1,200 kw. rotary converter equipments and one large storage battery. The storage battery has a rated capacity of 2,240 kw. for one hour. An exterior and interior view of the 42nd and Wabash avenue substation is shown. These views are typical of all the substations of the Chicago City Railway Company.

At the time of the organization of the Board, the Chicago Railways Company had two steam power plants in operation; one at Hobbie street on the North Side, and one at Western avenue and Washington street on the West Side, both of which stations generated direct current for the use of the railway. In addition to the current generated at these substations, some current was purchased from the Consolidated Traction Company, and the old Cable Plant at Van Buren street and Washington street was being converted into a substation, the Company obtaining 25 cycle—9,000 volts—3 phase current from the Commonwealth Edison Company's high tension lines, and delivering 600 volts direct current to the railway feeder system. Since the organization of the Board, this substation has been enlarged and three new substations are in the course of construction; one located at Sheffield and Lill avenues on the North Side; one at Leavitt street and Blue Island avenue on the Southwest side; and one at Grand avenue and Fortieth avenue on the Northwest side. The capacity of these substations is 6,000 kw. each; a total of 18,000 kw.

There is now being installed at the Sheffield avenue and Lill avenue station, and the Leavitt street and Blue Island avenue station, 4,000 kw. each, and the first installation at Grand avenue and Fortieth avenue will be 4,000 kw., leaving a reserve for these three stations of 6,000 kw.

There is installed and in operation at the Van Buren street substation 10,000 kw., and an additional unit of 2,000 kw. being installed, which will make the installation up to date for that station 12,000 kw.

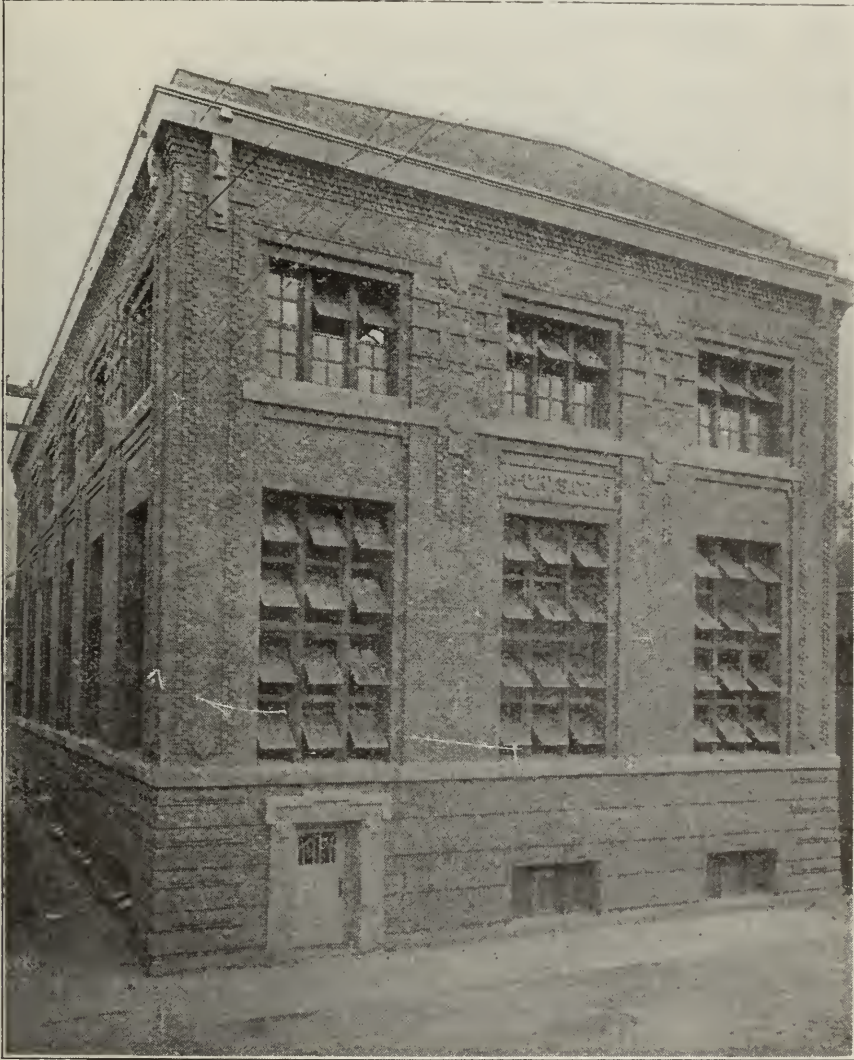
The old cable plant at Milwaukee avenue and Cleaver street has been rebuilt, and the boiler room section of the station converted into a substation. Total ultimate capacity 8,000 kw. Present installation, 4,000 kw., and an additional 2,000 kw. unit is being installed.

There is also under consideration the location of a substation on the North Side, somewhere in the vicinity of Devon avenue, of 6,000 kw. capacity, making a total substation capacity when completed of 44,000 kw. for the Chicago Railways Company.

The new substations that are being constructed by the Chicago Railways Company are designed of fireproof construction, with pressed brick walls, both inside and out, book tile roofs, carried on

structural steel trusses, and composition roof covering, concrete floors with composition wearing surface.

If time permitted, it would be interesting to describe in detail these substations, the design and equipment of which, as well as the quality of material and workmanship which is used throughout their construction, is believed to approach the highest standard of engineering practice.



Electric Substation, Lill Ave., near Sheffield Ave.

Division K—Cars and Car Operation—was organized in July, 1907, and its work consists chiefly of the working out of dimensions, weight, lighting, braking, ventilation, and other features that enter into the construction of typical modern double truck cars for street railway service, as are outlined in and contemplated by the Traction Ordinances.

The car that has been adopted as standard up to the present time
October, 1909

is what is known as the Pay-As-You-Enter car, seating 40 passengers.

The standard car of the Chicago City Railway Company is 48 ft., 3 in. in length and 9 ft. wide, over all. The platforms are 7 ft., 11 in. long over all, and 6 ft., 11 in. long inside, affording large, and commodious loading floor space.

The Chicago Railways Company are now building 650 cars of the Pay-As-You-Enter type 49 ft., 2 in. in length and 8 ft., 9 in. wide over all. Length of vestibules 8 ft., 4½ in. over all.

Special attention has been given to lighting and heating. The lamps for interior illumination are placed one over each seat, and are frosted globes, doing away with the glare of the ordinary incandescent bulb, and providing a soft and pleasant light. The heaters are electric and possess the advantage of compactness, light weight, cleanliness, flexibility of regulation, etc. Special heaters are provided on the platform for the comfort of the motorman and conductor.

The cars are equipped with sliding disappearing or folding steps, thereby making it possible to have the side of the car in the center between tracks or the non-loading side of the car closed, and no protruding steps or other parts permitting hitching on or standing on the outside, thus eliminating the possibility of accident from that source.

Cars are equipped with both air and hand brakes. The motor equipment consists of 4—40 H.P. motors per car.

Of the 650 cars under construction by the Chicago Railways Company, 600 are composite construction with steel underframes, and wooden body, and are being built by the Pullman Company. The remaining 50 are all steel cars, being built by the Pressed Steel Car Company at McKees Rock, Pennsylvania.

To our Chairman, Mr. Bion J. Arnold, is due the credit for the purchase of these steel cars, as he, in connection with his work on the New York subway problem, recognized the advantage to be gained by the operation of steel cars in subways rather than wooden cars. Inasmuch as we hope to have a subway in Chicago some time in the future it was concluded wise to begin the study of the construction of steel cars and their maintenance, cost, comparative life, etc., hence the 50 cars now in course of construction. The design of these cars, as far as dimensions over all, general interior arrangement and general appearance, are identical with the wooden cars being manufactured by the Pullman Company, but with the exception of the doors, car steps, trolley board, and maple floor strips, the cars are steel construction and practically fireproof throughout.

Division P—Tunnels and Subways—was organized in February, 1908, after the acceptance of its ordinance by the Chicago Railways Company. The Ordinances to that Company provide that it shall rebuild the tunnels under the Chicago River at La Salle street, and

Washington street; and plans and specifications have been prepared for a double bore reinforced concrete tunnel at La Salle street, so designed that it can be connected with and become part of any subway system that may be designed in the future, and provisions for temporary approaches from the surface so that the surface cars operating between the North and South Divisions of the city can have the benefit of this tunnel in the operation of cars to relieve the present congestion on the bridges. It is expected that contracts will be let covering the construction of this tunnel in the near future.

Plans and specifications are also under way for the complete reconstruction of the Washington Street Tunnel, which will be designed for connection to any system of subways that may be built in the future, and also with temporary approaches to the surface. Plans have been completed for a section of this tunnel on the west side of the river between Clinton and Canal streets, and a contract has been awarded for this part of the work to be carried on in conjunction with the construction of the terminal station of the Chicago & Northwestern Railroad, which crosses Washington boulevard at that point.

The Drafting Department—was organized under a Chief Draftsman who has general supervision of the work performed in the department and of the various systems and records required. Reporting directly to the Chief Draftsman are a clerk and four squad foremen; each of these is held directly responsible to him for the correct and proper execution of the work performed under his supervision. Each squad foreman is assigned to a special class of work and as the needs or demands of that particular work require draftsman or tracers they are accordingly detailed in order to secure the best and most desirable results. The Chief Draftsman receives instructions from the Division Engineers respecting the engineering details and design of the drawings made for their respective divisions, all of which work is under the immediate direction of the Assistant Chief Engineer. The drafting department is also called upon to supply all sketches and drawings required by the different divisions and also to meet the demands for minor jobs consisting of printing, binding, pasting, mounting, labeling, rolling, folding, indexing, etc.

All drawings are on standard size sheets, which sizes are multiples of the regular letter size sheet— $8\frac{1}{2}$ in. by 11 in., and the other sizes can be folded down to $8\frac{1}{2}$ by 11 in. for filing purposes.

No. 1. $8\frac{1}{2}$ by 11 in.

No. 2. 34 by 22 in.

No. 3. 34 by 44 in.

and in addition drawings that are larger than size No. 3 are called "Rolls" and are designated in size as "R" drawings.

For convenience each division has a classification letter which cor-

responds with the letter used in the classification of accounts by the American Street Railway Accountants Association.

Track and Roadway—Division D.

Electrical Transmission—Division E, etc., and drawings are indexed to denote the size of sheet and division as follows:

Track and Roadway—Division D drawings.

No. 1—D.

No. 2—D.

No. 3—D.

R—D.

Electrical Transmission—Division E drawings.

No. 1—E.

No. 2—E.

No. 3—E.

R—E.

and the drawing number for each drawing follows. The filing system consists of six groups or divisions:

Domestic Tracings.

Domestic Blueprints.

Folios.

Foreign Prints.

Catalogues.

Miscellaneous.

The Division of Accounts—was organized in May, 1907, and has charge of checking all expenditures that relate to the cost of rehabilitation, and to ascertain with the assistance of reports from the Engineering Divisions whether or not such expenditures are reasonable and to determine whether such expenditures are proper charges to Capital Account, in accordance with the rulings of the Board; and to determine whether proper reserves have been created and are maintained by the Companies as set forth in the Ordinances. Also to keep account of all expenditures made by the Board in the carrying out of its duties, which expenditures, in accordance with the terms of the Ordinances, are to be added to Capital Accounts of the railway companies during the period of rehabilitation, and after that period are to be charged to operating expenses.

Capital Account money is new and additional money put into the property to improve and extend it, and is obtained from other sources than the cash receipts of the Company.

The Ordinances provide that out of the gross receipts of the Company shall be paid—

1st. The operating expenses, including taxes.

2nd. The ordinary repairs to the physical property for which a sinking fund is provided, the minimum amount of which shall be 6% of the gross receipts per annum.

3rd. The renewals or depreciation of the physical property for which a sinking fund is provided, the minimum of which shall be not less than 8% of the gross receipts per annum.

4th. Out of the gross net earnings remaining after deducting the above charges, the Company may retain 5% upon the capital account as approved by the Board of Supervising Engineers.

5th. The remaining net earnings are divided 55% to the City and 45% to the respective Company.

During the rehabilitation period of three years from the date of the acceptance of this Ordinance, a special manner of accounting is provided, covered by the following quotation from the Ordinances:

"The said Board of Supervising Engineers shall have power
"to determine what work shall be treated as construction, re-
"construction, equipment, re-equipment, extensions, new lines,
"underground trolleys or additions to plant or property to be
"paid for by the Company out of the capital funds to be
"provided by it for that purpose, and what shall be treated as
"maintenance, repairs and renewals, to be paid for out of the
"gross receipts of the Company from the operation of the street
"railway system hereby authorized. But any such determin-
"ation of said Board shall be governed by the following pro-
"visions:

"During the three (3) year period of "Immediate Rehabil-
"itation" seventy (70) per cent of the gross receipts shall be
"set apart and shall be used so far as required in defraying
"the operating expenses, including maintenance and repairs,
"and the residue of said seventy (70) per cent. shall be ap-
"plied to the cost of renewals and no part of the cost of any
"renewal paid for out of such seventy (70) per cent. shall be
"charged to additional capital, and all expenditures for re-
"newals during said three (3) years in excess of such residue
"of said seventy (70) per cent. shall be charged to capital ac-
"count.

"After such three (3) year period of 'Immediate Rehabil-
"itation,' the cost of renewals shall be paid as provided in
"Section 16 hereof, but such expenditures (and only such ex-
"penditures) as are made for the purpose of extensions of or
"additions to property shall be thereafter considered as addi-
"tions to capital, provided, however, that in the replacement of
"any principal part of the property, either existing or hereafter
"acquired, there shall be charged to capital the excess amount
"that the new property cost over the original cost of the prop-
"erty displaced, excepting that the value of property contained
"in the appraisal inventory of the property of the Company,
"referred to in Paragraph 1 of Section 20 hereof, shall be used

"instead of first cost for all property listed in such appraisal
"inventory."

Each Division Engineer has, as a part of his organization, Inspectors, who, in addition to their other duties, render to him on forms daily, semi-monthly and monthly reports of the quantities and amounts of material used and hours of labor expended on each piece of work in progress. These reports are used by the division engineer as a basis for the monthly estimates and also as a check upon the expenditures made by the railway companies and reported by them to the Division of Accounts. Thus, a counter check from two entirely independent sources are secured; from reports of the railway companies checked and summarized by the Division of Accounts and from the field reports of the Division Engineers. If time would permit, a much more detailed account of the workings of the division of accounts, and the methods of checking the amounts expended on the rehabilitation work by the different engineering divisions would probably be of interest.

Mr. William B. Jackson, M.W.S.E.: I regret that Chairman Abbott had to leave for a train, so that we cannot have the pleasure of hearing further from him tonight. I wish to express, for both Societies, our great appreciation of the talks that we have had this evening.

In connection with some of the matters that were brought out by Mr. Fleming and Mr. Weston regarding the question of blanks that are in use by the traction companies, and the matter of typical designs for substations, car barns, etc., the Societies will certainly appreciate any designs that may accompany the papers for use in the proceedings, so that, although it was not possible to explain in detail many of these designs, we shall have the opportunity of studying them in the JOURNAL of the Society.

We have with us tonight one of the men who has been much interested in all traction problems of Chicago and who has been in this work for a long time, and I take pleasure in calling upon Mr. B. I. Budd, General Manager of the Metropolitan West Side Elevated Railway Co.

Mr. B. I. Budd: I have listened with much interest to the outline of the great work being carried on by Mr. Arnold and the Board of Engineers. There is one question I would like to ask in regard to the work of rehabilitation. The congestion, delays, and consequent loss of time in getting cars through the heart of the city at the present time would indicate that, even with the present amount of new equipment operated, the tracks have nearly reached the limit of their capacity, and I would like to hear from one of the Board of Engineers what their plans are to relieve this congestion.

Mr. Arnold: Of course we cannot make any more streets in the city than we now have. If we could we would, for we need them. But it is expected when we get these tracks all reconstructed, in accordance with the terms of the ordinances, that the cars will be

so re-routed by means of the through routes that the congestion now existing will be relieved; in other words, many of the cars which now come into the down town district, around the loop, and return, will then run through, thus relieving the congestion.

Chairman Jackson: We are all looking forward to this through routing. I remember how I was looking forward to it when I was living on the North Side near the lake last year. I was thinking about how pleasant it would be to go right to my office on the North State Street cars. Then about the time we had that through route, I moved further out and missed the opportunity to use it, but my experience gave me a lively appreciation of the need and advantages of the through routing.

Mr. Arnold: Just a word further; we are now substituting single cars for trains, thus putting one car on the street in place of two; in many instances this will tend to relieve the congestion that Mr. Budd speaks of, also, the additional power on the cars being larger motors, gives a more rapid acceleration and enables us to increase the speed of those cars about 11%, which also tends to help relieve congestion. I might also state that we hope in the course of time to have subways, for which we all ought to work. As a general proposition, we need all the space on the surface of the present streets, we need all the space under the streets, and we may need all the space above the streets, to take care of the traffic of this city in the years to come.

Chairman Jackson: We have heard much of great interest regarding the mechanical features of the street railway construction and regarding the franchises, etc. Every foot of this system uses electric power in its operation, and aggregates in length of single track a distance equal to that from New York to Boston. I believe there are some 75,000 to 80,000 kw. of rotaries, operated from the great central power plants of the city, which supply electric energy to the system, and I will ask Mr. Junkersfeld, who is the Electrical Engineer of the Commonwealth Edison Company, to tell us something about the electrical distribution required for the system.

Mr. P. Junkersfeld, M.W.S.E.: I have been very much interested and very much instructed by what we have heard here this evening. One of the underlying theories of the ordinances, as I understand it, in addition to what has already been said, was to give the best possible service for the present rates of fare, and that takes into account, of course, everything, including the power. The Commonwealth Edison Company, as has been said, furnishes at the present time motive power for the City Railway and quite a large amount for the Chicago Railways. At this time such power is all generated in two power houses, one at Fisk street, which is known as the Fisk Street Power Station, and the other one, which is across the river therefrom, known as the Quarry Street Station. Those two power houses are sufficiently familiar to most of you to require no further description, except perhaps the general statement that the Common-

wealth Edison Company in supplying this power, has likewise kept in mind that the best possible service that can be rendered is the only one that is acceptable and the one which is in line with this great development going on in the traction situation. We have spared no expense, and the best and most modern equipment that can be secured has been installed and is used to furnish this power. In the transmission system as well, every precaution known to the best modern practice is used and taken to guard against accident or interruption.

Mr. D. W. Roper, M.W.S.E.: In his remarks about the division of the receipts, Mr. Arnold told us how certain parts were paid for operating expense and certain other parts for depreciation of parts and to add interest on the investment, and 55% of the remainder or net receipts went to the city as its compensation. I would like to inquire what percentage of the gross receipts the city's compensation approximates.

Mr. Arnold: I have not the figures exactly, but I will say during the two years that we have been in operation we have put into the city treasury very close to \$3,000,000. If you will figure that up I think you will find it is approximately 8% of the gross receipts for the two years.

Now, let me make that point clear. When these traction ordinances were under consideration, that question, you remember, was made a feature of the campaign prior to the adoption of the ordinances by the city. Certain people having the interests of the city at heart requested that the ordinance be so modified as to stipulate that this 55% of the net receipts should never be less than a certain per cent. of the gross receipts, they contending for 10%, I believe, of the gross receipts. That question was put right up to myself, who was the engineer representing the city at that time, and Mr. Weston, my assistant at that time, and we spent many nights working out the probable results for the period of twenty years covered by these ordinances. We found that we could not recommend that the railway companies guarantee the city 10% of the gross receipts and at the same time require them to build the kind of a railroad that we, as engineers, said the city ought to have; consequently we told the gentlemen who were interested in it—a very important body of men in the city, all having the interests of the city at heart—that it could not be done; that if they wanted a railroad such as we thought they ought to have, they had better waive the 10% of the gross receipts feature and take 55% of the net receipts; if they demanded 10% of the gross receipts, the investment would have to be so low that we would not get a good railroad. The result was, it was decided not to change the ordinances. Those advocating the ordinances stood upon the ordinances as they read, namely, 55% of the net receipts, and this was ratified by the people, as you know, by 35,000 majority. There may be times when it will be 10% of the gross, but the average for

the period according to our estimates, was approximately 8% of the gross receipts.

Chairman Jackson: Are there any further remarks or questions? If not, I will ask Mr. Arnold to speak in closure for the Board of Supervising Engineers.

I would like to ask how the value of real estate was determined, and whether the railroads were given the benefit of the advance in the value of the real estate up to the time of the appraisal? Also what was done in the matter of such costs as legal expenses, cost of marketing and securities, incidental expenses, etc.

Mr. Arnold: The question of real estate, I will answer first. We took an appraised valuation of the real estate at the time the valuation was made, June 30, 1906. That valuation was determined by real estate experts whom we employed, familiar with property values in the city; they went out and examined the properties. The railroad company sent one expert and the city sent one expert. They submitted their figures to us independently, and when the differences were too great we asked them to go back and look at the properties again. The result was that they finally came to conclusions on every piece of real estate and those are the values we accepted. Those values recognize whatever increase had been made in the properties from the time they were purchased by the companies to the time of the valuation. Consequently we took the actual valuation of the properties. The companies contended for certain expenditures which they had made in the way of bridges and other city improvements, concessions to the city for the right to lay tracks in the streets, which of course had cost the companies money. Certain facts were more or less recognized in fixing the compensation. When we thought an article should be allowed we allowed it; but we did not allow anything for construction of bridges, reconstruction of bridges or things of that character, because we thought that they had had the use of the bridges long enough under the ordinance to compensate them for any expense of that kind.

In general, I may state that this whole question is a vital one at the present time. As some of you know, I am appraising all the street railway properties in New York, in Brooklyn, and in Detroit, and this question Mr. Jackson has raised comes up at every place and is a very serious one. I do not know that I have clearly settled in my own mind what we will do, but in general such expenses are always impediments in the way of getting properties together. For instance, when you consolidate properties you generally have to have a capitalization of more than they originally cost, because somebody makes a profit, and such promotion expenses, legal expenses, and other expenses of that character, which go into the creation of a property, should probably be put into a fund to be charged off gradually over a period of years, so that finally the property will not have to carry the burden of them, in

its capitalization; and that is about the position I am getting to, although I have not absolutely taken that stand yet.

Chairman Jackson: In other words, you aim to protect the stockholder and at the same time protect the people?

Mr. Arnold: Yes, and protect the man who builds the railroad in the first place. He can not create the railroad without incurring those charges, because they must be incurred, and in order that he may finally get his money out of them, the theory is that he should have a certain number of years during which a percentage of these charges should be charged off each year, so that finally the capitalization is reduced by that amount. Then the innocent purchaser in future only pays upon the real value of the property, promotion charges having been wiped out. The English have some such plan as that, and it seems to be a pretty good one.

I don't know that I can add much further information to either of the questions we have just been discussing. We can talk about them all night, because there are so many elements that enter into them. What are promotion charges? What are proper charges to capitalization? How long a period of time should we charge it off in? What kind of a fund should we create? What would we do with that fund while creating it? Those are things that are vital and have got to be settled in the near future in this country. It is a live question in every city that has a traction question.

I wish to express my appreciation, on behalf of the Board of Engineers, for the opportunity which you have given us to appear before you to-night and talk about our own affairs, and I hope that we have been able to give you some information that may be of possible value to you.

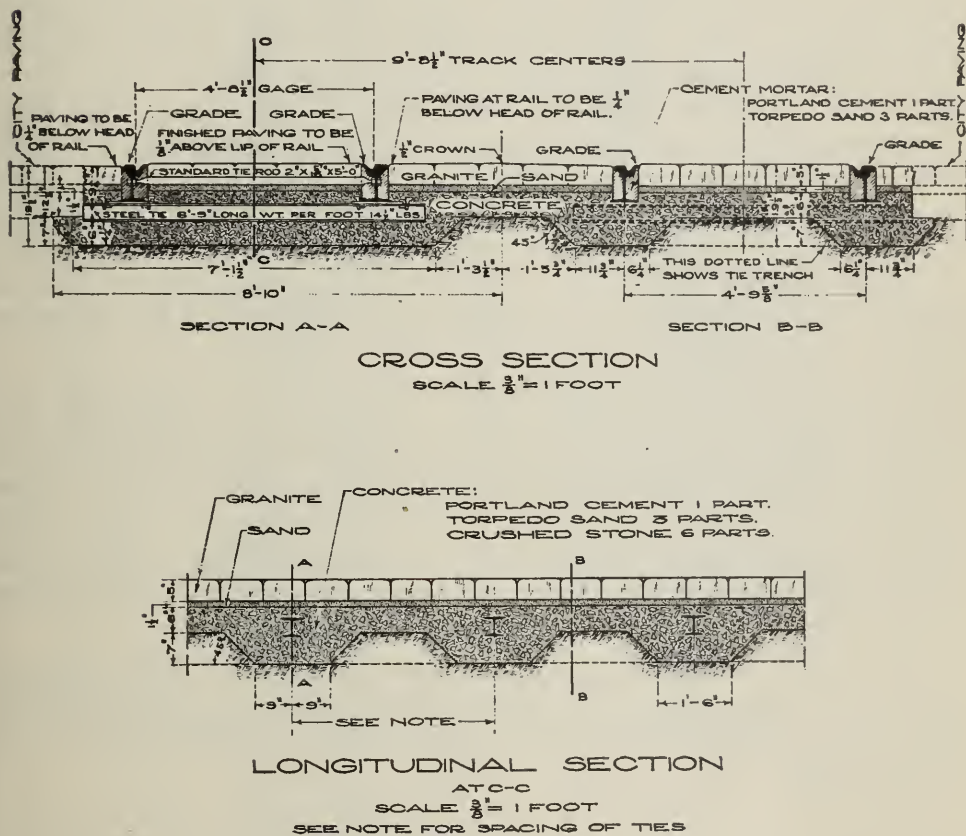
RECONSTRUCTION OF STREET CAR TRACKS IN CHICAGO

GEORGE WESTON, M.W.S.E.

Presented June 16, 1909.

In presenting this paper it is not claimed that anything specially new in Track and Roadway Engineering has been developed in the plans and methods that have been adopted for the reconstruction of the street railway tracks of Chicago; however, the use of screw spikes and treated ties may be new in their application to street

TYPE #1.



NOTES:

- OUTSIDE RAILS TO BE 1/4" LOWER THAN INSIDE RAILS.
- PAVEMENT TO BE GRANITE BLOCK AS SPECIFIED IN ORDINANCE FEB 11TH 1907, UNLESS OTHERWISE ORDERED.
- ON CABLE CONSTRUCTION SPACE TIES SAME CENTERS AS CABLE YOKES.
- ON ALL OTHER WORK SPACE TIES ON 4'-0" CENTERS.
- PAVEMENT TO BE SWEEPED WITH DRY GRAVEL ONLY.

Fig. 1.—Track Construction with Steel Ties.

railway track construction. The grooved girder rail used is specially designed to meet the requirements of the "Municipal Code of Chicago" (which specifies that, "grooved girder rails shall be used in the streets"), and to provide a rail of that type that would give as great a life as possible under the traffic conditions of this City.

It is the purpose of this paper to describe the different types of track construction adopted, the theory upon which the designs are based, and an explanation of the use of the different materials employed to carry out the theory, with the hope that it will bring out a thorough discussion of the subjects.

Theory of Design: The principle object sought by the design of track construction submitted herewith was permanency of construction with minimum maintenance, depreciation and renewal expense. Inasmuch as the rails and joints of a track are subject to direct and continuous wear and must in time be renewed, the track has been divided, possibly arbitrarily, into what we term a "superstructure" and a "substructure." That part of the track that must be renewed being styled the superstructure, consisting of rails, joints, and possibly the tie fastenings; and that part of the track not subject to direct wear, or necessarily affected by the operation of renewing the superstructure, has been styled the substructure, consisting of ties, ballast, etc. (The subject of paving will not be referred to here in detail, as pavement is considered to be a separate item.)

From the brief description given above it will be seen that the theory of our track construction consists of a permanent substructure that will not depreciate and a superstructure that can be renewed when necessary without disturbing the substructure. There has been developed and approved by the Board of Supervising Engineers three types of track, each type differing from the others in the character of the substructure and tie fastenings. These types are as follows:

Type No. 1: Consists of a concrete foundation with steel ties, spaced four feet, center to center, entirely embedded in concrete, and with a specially designed renewable clip and wedge for rail to tie fastening.

Type No. 2: Consists of a concrete foundation with wood ties, spaced four feet, center to center, entirely embedded in concrete, and with tie plates and screw spikes for rail to tie fastening.

Type No. 2-A: Same as Type No. 2, excepting that the ties are spaced three feet, center to center.

Type No. 3: Consists of a rolled, broken stone foundation, with wood ties, spaced two feet, center to center, and with tie plates and screw spikes, for rail to tie fastening.

Careful study and thorough discussion were given to the subject of track substructure by the Board. In some cities a type of track

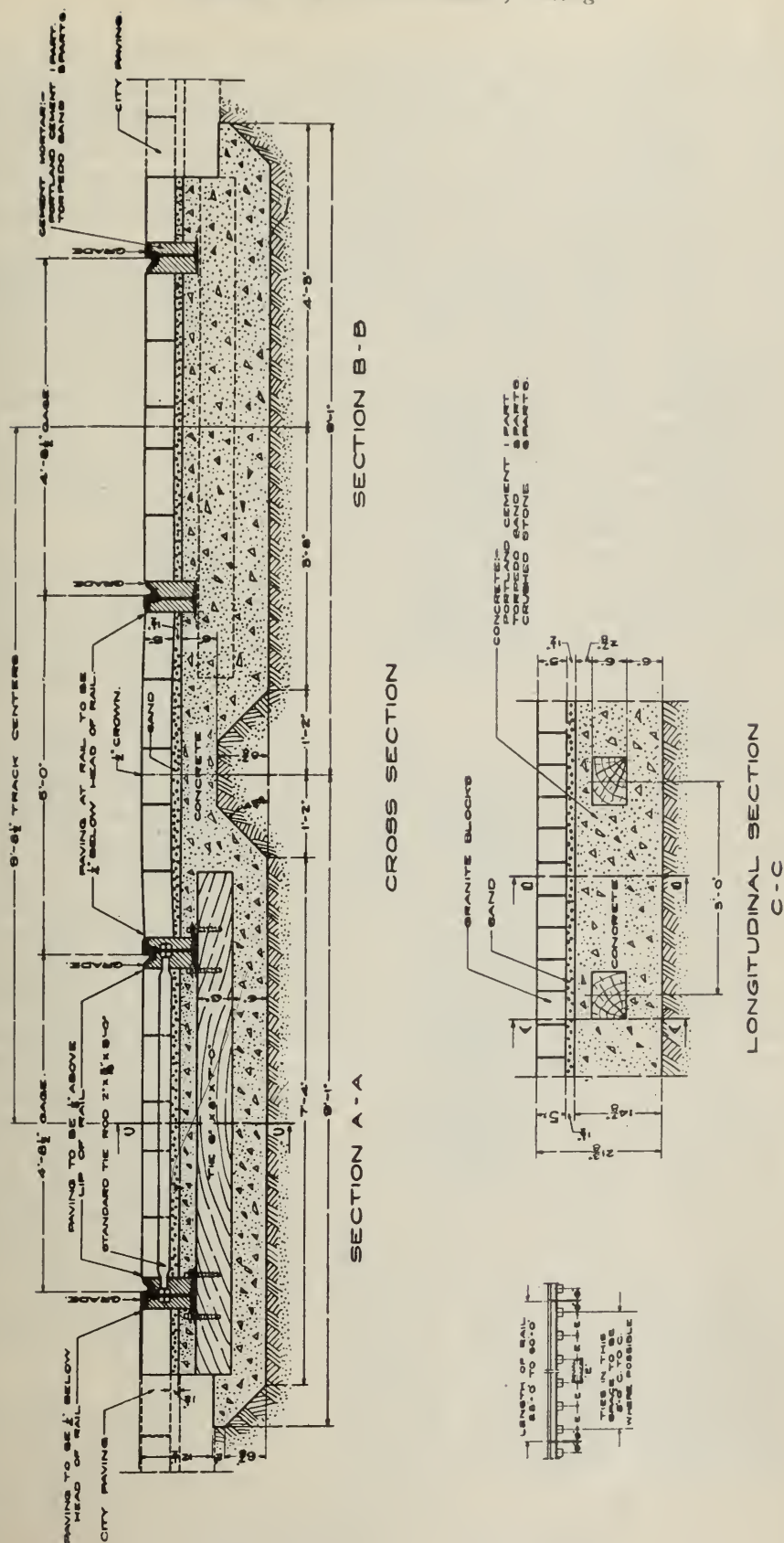


Fig. 2.—Wood Ties in Concrete.

construction known as "Beam Construction" has been used, where the rails have been laid in concrete with an increased amount of concrete directly under the rail forming what is termed the "Beam." In some instances without ties, and, in other cases, with the ties at joints and centers or joints, centers and quarters, to assist in surfacing and lining the track. Unsatisfactory results have generally followed the use of this type of construction.

Track has been constructed in the cities of Montreal and Toronto, Canada, where "T" rails and also girder rails have been laid on a concrete foundation without ties, no attempt being made to fasten the track down. The concrete foundation is first laid and the rails are strung out upon it as they would be upon a floor, spliced, tie rods placed, lined, surfaced, grouted and paved. The writer rode over track in these cities that was constructed in this manner and which had been operated about one year, and was, at that time, in apparent good condition with no evidence of failure.

Independent sets of bolt fastenings were considered as a substitute for ties, to be set into the concrete "foundation bolt" fashion, a separate line for each rail spaced four or five feet center to center. This type of fastening has not been used, the type with cross ties being considered better construction, and it is shown here simply to illustrate the text.

The subject of the use of ties in track construction was given thorough study and consideration, and it was the final unanimous opinion of the Board that it was of prime importance to have the rails in the track, tied together independent of the concrete, and the use of ties was, therefore, determined upon.

The substructure in Type No. 1 track, has the elements of permanent life, to-wit: Steel ties embedded in Portland cement concrete. The fact has been quite thoroughly established that steel embedded in concrete is protected from corrosion, and therefore, permanent life can be expected from Type No. 1 foundation, if motion can be prevented between the tie and the concrete, which otherwise would tend to cause disintegration of the concrete and consequent failure of the foundation. While, with the use of steel ties, all members of the Board were of the opinion that the resulting foundation contained the elements of permanency as regards materials, the question of rigidity of the track and the presence or absence of sufficient resilience or cushioning effect to absorb shock and vibration was discussed at length, with the final result that the use of wood ties in Type No. 2 or Type No. 2-A track, meets with more favor, and today Type No. 2-A is practically the standard track adopted by the Board.

It is only practicable to build track with a concrete foundation when conditions are such that traffice will not be put upon it for a sufficient length of time to permit the concrete to become properly set. This can be done when long stretches of track are to be built and provisions can be made for re-routing the cars, or the con-

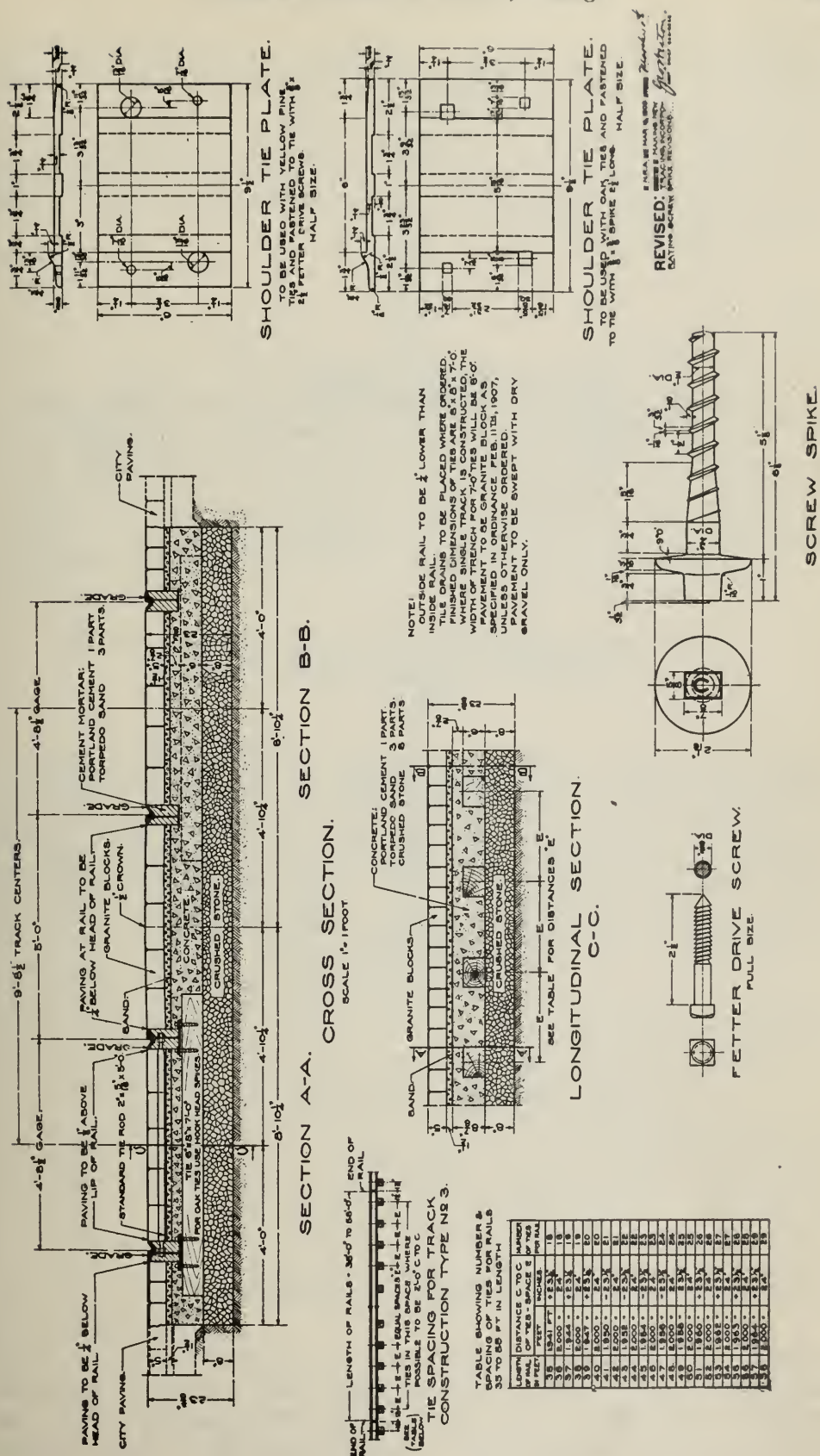
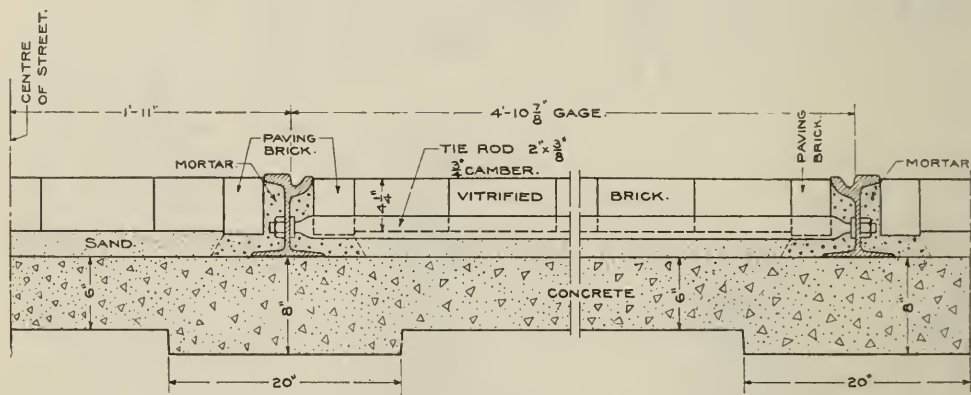


Fig. 3.—Wood Ties on Broken Stone.

Therefore, it became necessary to design a type of track that could be used for emergency, special work, unimproved streets, etc., and Type No. 3 has been adopted for such uses.

Materials: The steel tie used in Type No. 1 track is an "I" beam shape, weighing 14.5 lbs. per foot with one wide flange and one narrow flange. We use the tie inverted—that is—with the wide flange up to receive the rail.



CROSS SECTION.
7" GIRDER RAIL ON CONCRETE.
THE TORONTO STREET RAILWAY CO.

Fig. 4.

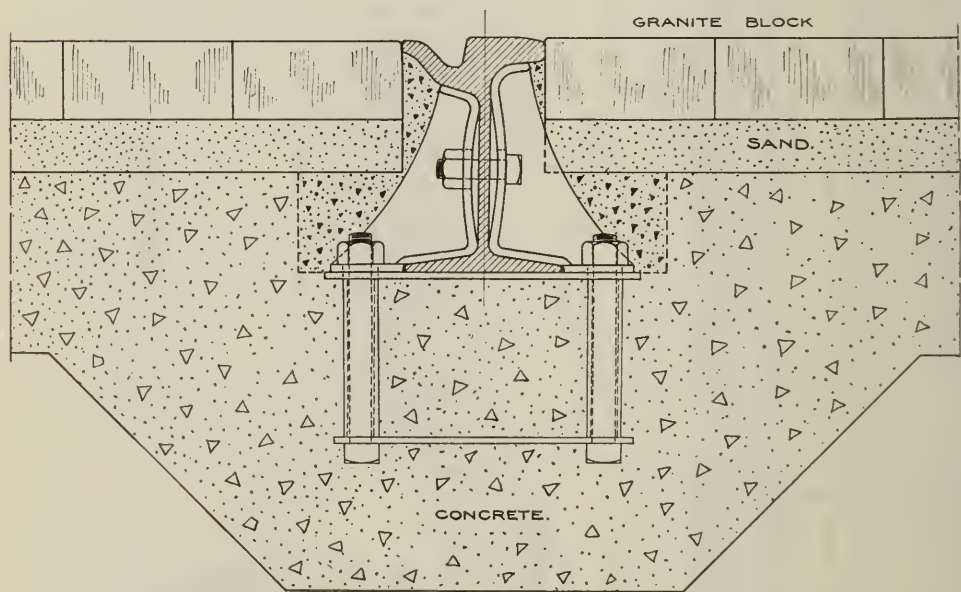
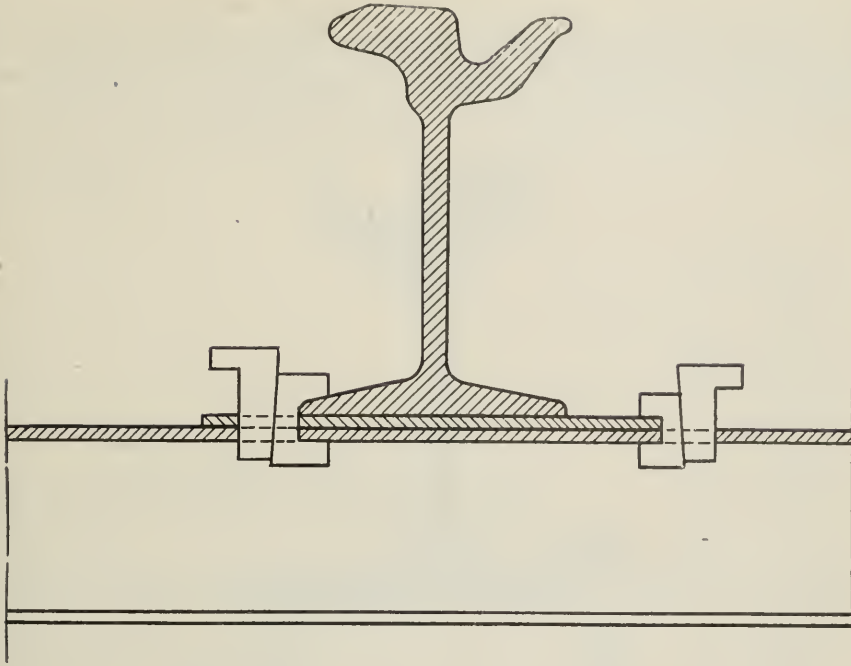


FIG A
ANCHOR BOLT TYPE.
CONCRETE TRACK CONSTRUCTION.

Fig. 5.

struction of a temporary track for their operation. Also, in the placing of special work, such as frogs and crossings, it is impracticable to attempt to use this type of foundation, and a concrete substructure should have a solid foundation of soil under it.



RAIL AND TIE PLATE FASTENINGS
STEEL TIE CONSTRUCTION.

Fig. 6.

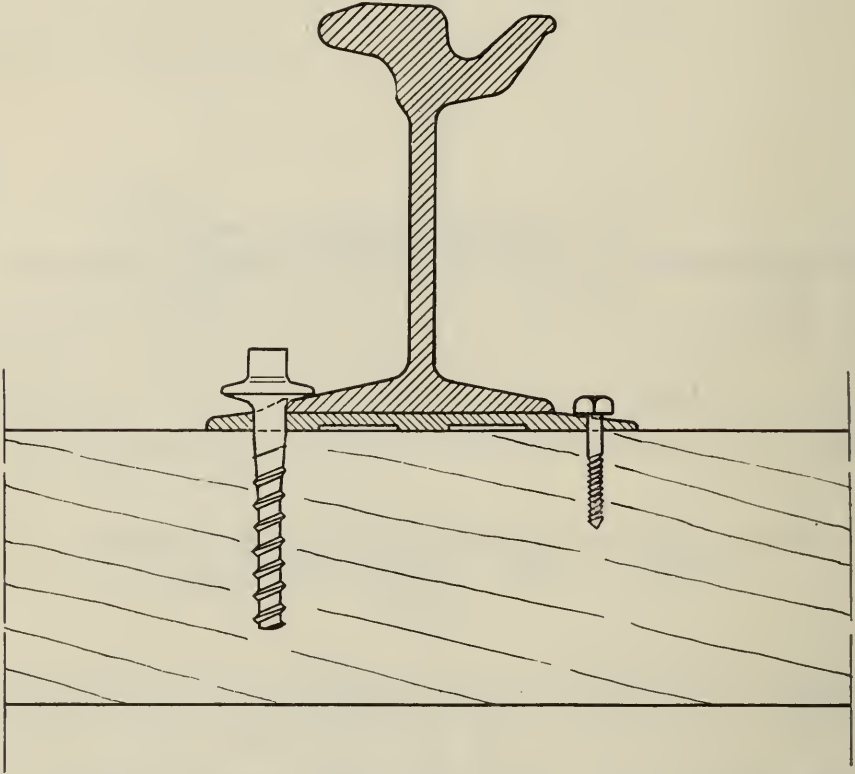
According to the theory of our construction, the tie becomes a part of the permanent substructure and must be protected from wear, and necessarily must not be disturbed in the operation of renewing the rails. A tie plate and "clip" fastening were designed (Fig. 6) to accomplish this result. By the use of special fastenings, independent of the rail fastenings, the tie plate becomes a part of the tie; *no movement* can take place between the tie plate and the tie, thereby protecting the tie from wear.

These tie plate fastenings are so designed that, at the time the rail is renewed, the tie plate can also be renewed without disturbing the tie. The rail is fastened to the tie plate and tie by a clip that can be removed and replaced without disturbing the tie.

The wood tie used in Types No. 2, No. 2-A and No. 3 track is 6 in. by 8 in. by 7 ft. 0 in. long, treated with chloride of zinc. In considering the use of the wood tie the subject of decay and methods of treatment for the preservation of the wood were considered. From information gathered, it was believed that timber incased in concrete would be preserved against decay, and our first specification for the manufacture of ties called for untreated, 90% heart, yellow pine ties.

The question of the life of the wood tie has direct bearing upon the length of life of the substructure. It being such an important factor the study of treatment of ties by preservatives was continued, and, after further discussion, it was the unanimous opinion

of the Board that the treatment of the wood ties by a preservative would be an added insurance against their decay sufficient to warrant such additional expense that might be incurred by the use of treated ties. After a very exhaustive study of the subject, it was the con-



RAIL AND TIE PLATE FASTENINGS
WOOD TIE CONSTRUCTION.

Fig. 7.

clusion of all members of the Board that where ties or timber are exposed to the action of the elements and subjected to rains and floods, the creosoting treatment was preferable, but for our use in street railway track, where the ties are encased in concrete and protected from the action of water, and with no opportunity for the soluble salt to be "leached" out of the timber, the chloride of zinc treatment was all sufficient and would preserve the ties against decay. Therefore, the standard tie as now used in the track construction is the chloride of zinc treated tie.

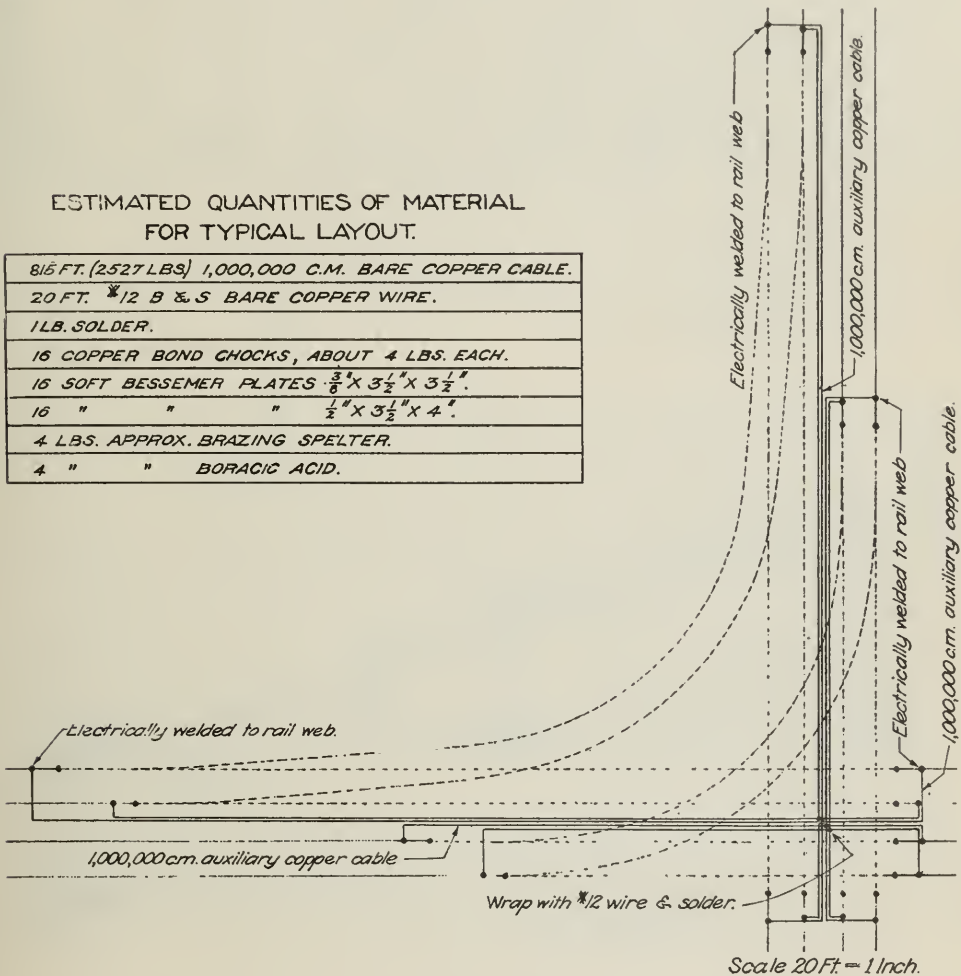
The treatment of ties with a preservative, permits the use of a wider range of soft woods, and our specifications for treated ties include the following timbers: "Long Leaf Yellow Pine, Short Leaf Yellow Pine, Loblolly Pine, Black Gum, Norway Pine, Oregon Fir, Cypress or Selected Red Oak."*

*Since the paper was read, Black Gum has been Omitted from the specifications for the treatment of ties, and Beech and Elm have been added.

The specifications for the antiseptic treatment of ties, covers the treatment by straight creosote and a combination treatment of zinc chloride and creosote, as well as the chloride of zinc treatment. The specifications require the treatment to be applied in retorts or cylinders properly arranged for a steaming, vacuum and compression process.

ESTIMATED QUANTITIES OF MATERIAL
FOR TYPICAL LAYOUT.

815 FT. (2527 LBS.)	1,000,000 C.M. BARE COPPER CABLE.
20 FT. $\frac{1}{12}$ B & S	BARE COPPER WIRE.
1 LB.	SOLDER.
16	COPPER BOND CHOCKS, ABOUT 4 LBS. EACH.
16	SOFT BESSEMER PLATES $\frac{3}{8} \times 3\frac{1}{2} \times 3\frac{1}{2}$.
16	" " " $\frac{1}{2} \times 3\frac{1}{2} \times 4$.
4 LBS.	APPROX. BRAZING SPelter.
4	" " BORACIC ACID.



NOTE:

All internal standard joints of special work bonded with 40 $\frac{1}{2}$ copper bond $\frac{3}{4}$ terminal.
Connect auxiliary cables to special work cables at crossing.

Fig. 8.

Our specifications provide that in the steaming treatment the temperature must not exceed 250 deg. Fah., and that the vacuum applied shall not be less than 26 inches of mercury, and the pressure used for impregnating the fluid shall not exceed 100 lbs. per sq. in., but provision is made for increasing this pressure when the creosoting process is used.

The specifications provide that, with the zinc chloride treatment the solution shall carry such percentage of chloride of zinc salt that the mean impregnation per cubic foot of timber, shall be $\frac{1}{2}$ pound of pure chloride of zinc.

It is essential that the wood tie be protected against destruction of the fibre by the action of the rail, producing what is termed a "channeling" effect. From the writer's observation, one of the principal causes for the failure of a concrete foundation track with wood ties has been the failure to protect the tie from abrasion produced by movement of the rail; the rail having been spiked directly to the tie with ordinary hook-head spikes, the spikes pulling out under traffic permits a movement of the rail which

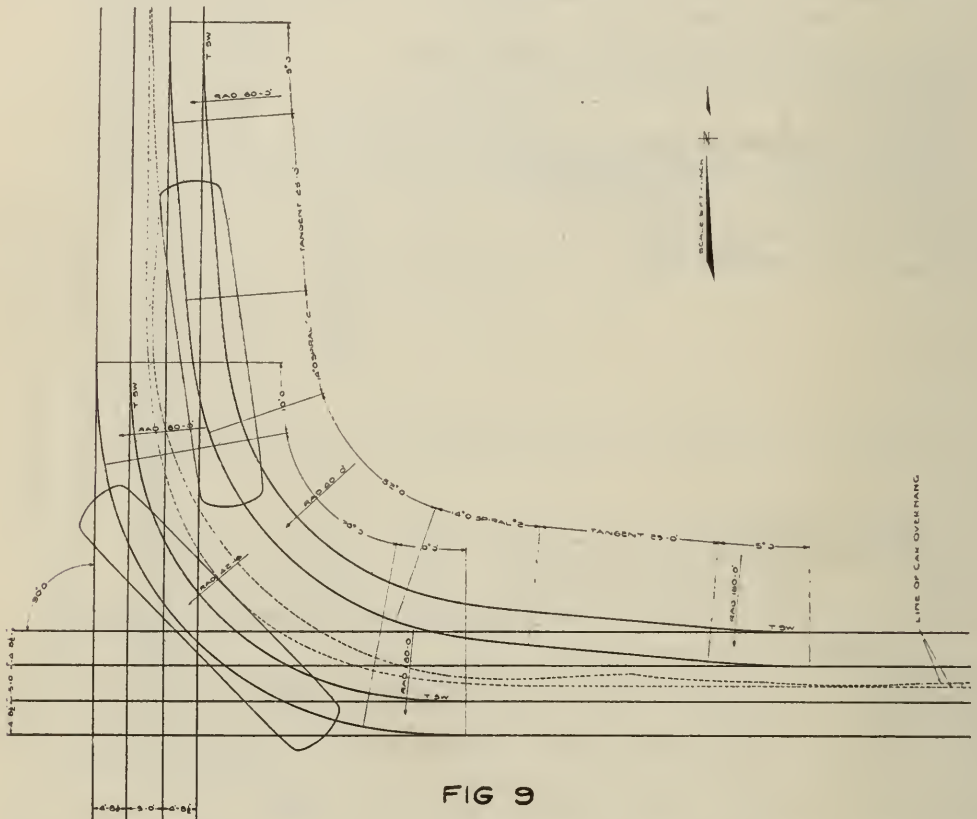


FIG 9

performs work upon the tie and destroys the fibre of the wood. In order to protect the tie thoroughly from the action of the rail, the tie plates secured to the tie by "fetter drive" screws; the plates thereby becoming a part of the tie. This tie plate can be renewed wherever the rail is renewed, without disturbing the tie, if it is so desired.

The rail is secured to the tie by screw spikes which are susceptible of being removed or replaced whenever it is desired to renew the rail without disturbing the tie.

To assist in holding the rails to line and gauge, the tie plates are provided with a "shoulder," and tie rods, 5/16 in. by 2 in. with 1 in.

round terminals, manufactured from solid bars, are used, spaced six feet, center to center.

The provisions of the ordinances of February 11th, 1907, passed by the City Council of the City of Chicago to the Chicago City Railway Company and the Chicago Railways Company, under which the Board of Supervising Engineers is working, provide under the head of "Bonding" in "Exhibit B" of these ordinances, that "There shall be some form of bonding used which will connect the ends of the rails in such manner that the conductivity of the joints shall be equal to the carrying capacity of the rail." After careful study of the rail joint question the Board of Supervising Engineers concluded that an electrically welded joint would fulfill the ordinance requirements as to conductivity, and with proper protection in the contract covering possible breakages, the joint was considered to be an advantageous one to adopt, and all of the straight track that has been built to date, under the ordinances, has been electrically welded at the joints.

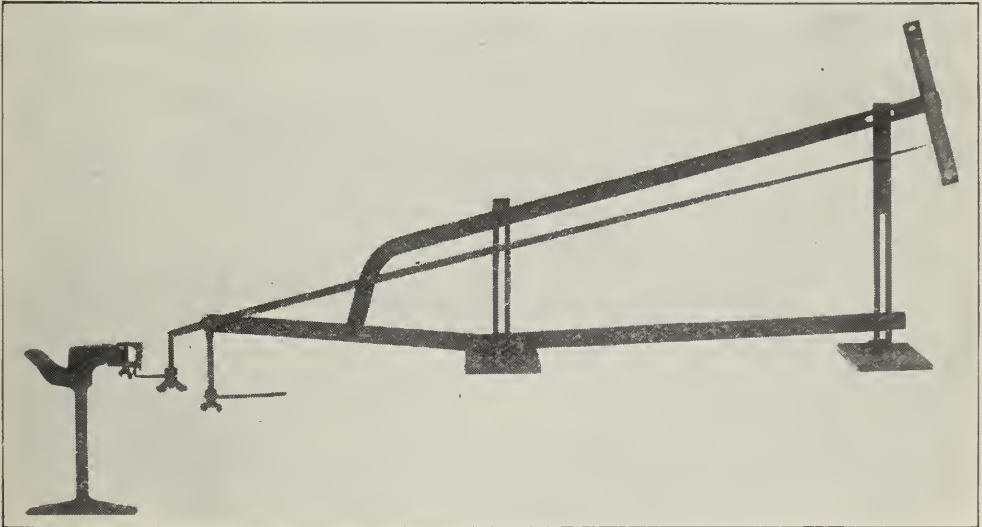


Fig. 10.—Measuring the Vertical Deflection.

On "special work," a bolted joint has been used, and, in order to provide for the continuity of the full conductivity of the rails through the special work, a copper cable is placed under the special work for each rail and its ends are welded to the web of the straight track rail outside of the special work. (These auxiliary copper cables are shown on Fig. 8.) The joints of this special work are bonded with a small copper bond to take care of what might be termed the "internal conductivity" of the piece of special work.

Careful study has been given the subject of track "special" work, and the very important point of providing passing clearances for cars operating in opposite directions on curves has been accomplished. In large cities where cars must be operated under close

headway, and where the congestion of the streets from vehicular and pedestrian traffic introduces delays to cars, cannot be entirely eliminated in the operation of cars upon the street surface, it is essential that delays from other sources should be reduced to the minimum. Consequently the elimination of delays to cars at curves will be a great factor in reducing the schedule time of the cars.

Owing to the rapid wear of track "special" work at frog and crossing points, particularly when the special work has been "built up" using ordinary rolled rail sections, the question of providing a "maximum wearing" metal to be used in such work has been given much study by the leading special work manufacturers, for the purpose, primarily, of producing a "maximum wearing" metal or a "hardened center" insert at the point of maximum wear, in order to make the life of the special work at these points of "maximum wear" equivalent to the life of the connecting rail, with the re-

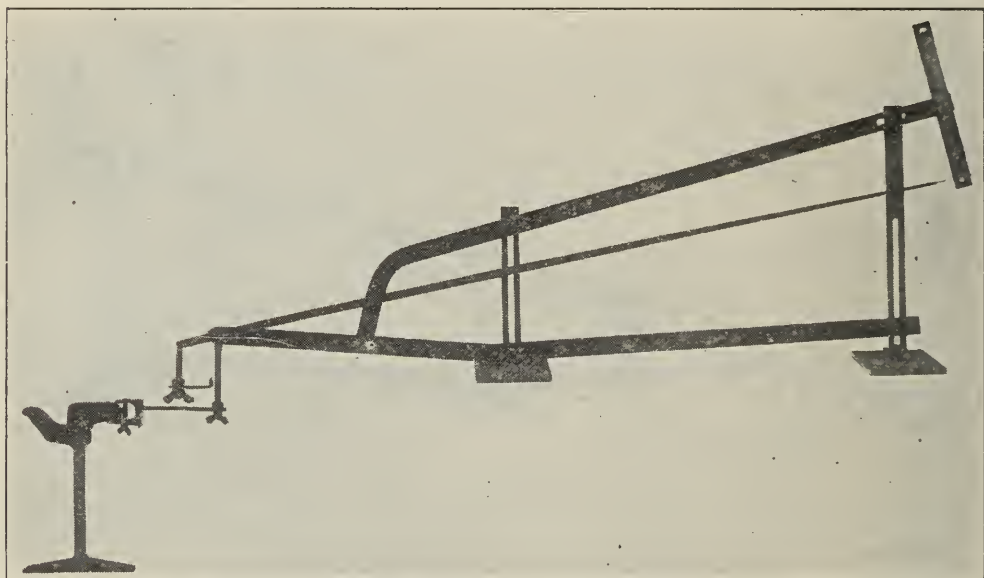


Fig. 11.—Measuring Lateral Deflection.

sult that metals have been produced that outwear the connecting steel rails; and it is very frequently the case in the life of "hardened center" special work that the rolled Bessemer steel connecting rails wear out before the frog point or crossing point.

The metal that has met with the greatest success is a steel alloyed with manganese, which, in its manipulation and annealing, produces a metal that is very hard and tough, but ductile, a metal so hard that it is not subject to rapid wear and is not brittle.

Such special work that wears rapidly is very objectionable by reason of the poor operating condition resulting from deterioration, and is most expensive from a standpoint of repairs and renewals, for the reason that, by comparison with straight track, the life of special work is short, and not only the cost of the special work

"layout" is involved, but the cost of removing the old and installing the new work must be considered. Therefore, if, by installing an improved class of special work at a reasonable additional first cost, its life can be increased, it is economy to do so.

In considering the question of special work, the Board of Supervising Engineers desired to design a type that would result in the greatest wearing life possible, and its plans and specifications, in addition to "hardened center" work, provide for switches, mates, frogs, and crossings of solid manganese steel and a large part of the special work that has been installed under the supervision of the Board, particularly upon trunk line, heavy traffic streets, has been of the solid manganese type.

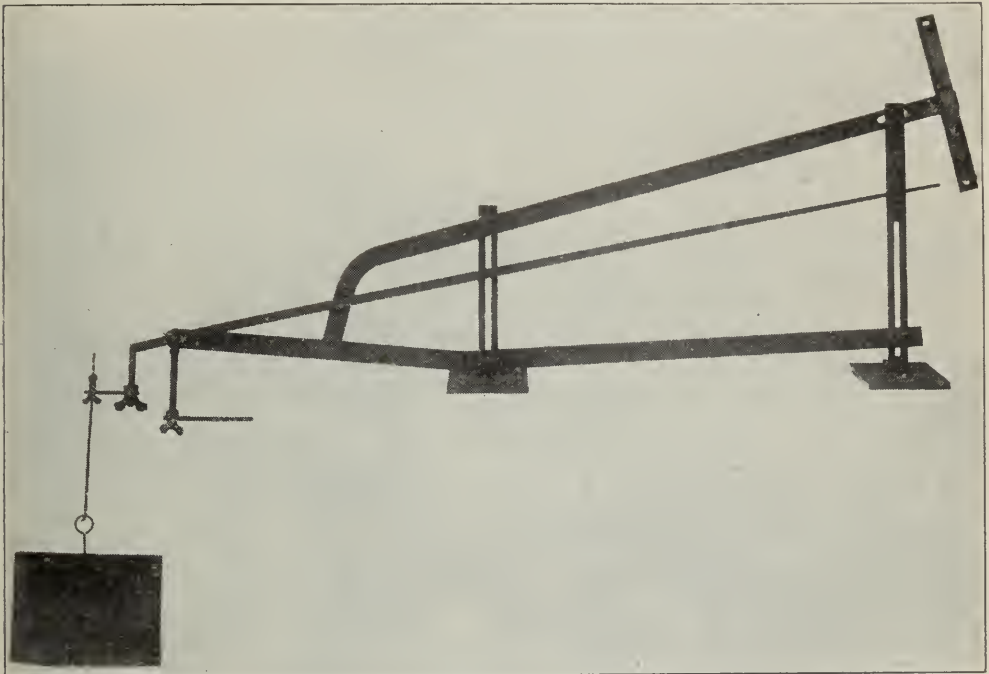


Fig. 12.—To Measure the Tie Deflection.

It has been considered that the concrete in the substructure is one of the most important parts of our track construction, and the specifications covering this part of the work have been drawn very carefully, and, in prosecuting the work, great care has been taken to have first class materials and thorough workmanship in mixing and placing. The specifications provide that the concrete shall consist of, "Portland cement—1 part, sand—3 parts and crushed stone—6 parts"; that the Portland cement shall conform to the "Standard specifications adopted by the American Society for Testing Materials"; "the stone shall be hard, durable and free from dirt, broken and screened and what is known commercially as one inch stone"; "the sand used shall be sharp, clean torpedo sand free from dust, loam and dirt." The specifications cover mixing by hand for emergency, but the mixing of the concrete for the general work

is done by machine under the following specification: "The constructor may use a machine mixer at the discretion of the Engineer in Charge. The necessary requirements for the machine will be that the precise and regular proportioning of materials can be controlled, and the product be of the required consistency when thoroughly mixed, and that, if the machine travels upon the track rails, the vibrations and the strains due to moving the mixer will not be sufficient to affect the line and grade of the track."

As stated previously in this paper, the specifications require that the track shall stand fourteen (14) days after the concrete has been placed, before cars are allowed to be operated thereon.

Where the pavement on the outside of the track is asphalt, or of similar character that can be swept and cleaned, the stone and sand are deposited directly upon the clean pavement, but on unpaved streets, or where the pavement is of such character that it cannot be thoroughly cleaned prior to the depositing of the concrete materials, a floor of planking is laid upon the street to receive the concrete materials.



Fig. 13.—Mixing and Placing Concrete in the Track.

The spaces under the heads of the rails and next to the webs are filled with a Portland cement mortar, composed of one (1) part Portland cement and three (3) parts torpedo sand.

In order to provide a thoroughly solid foundation, the trench prepared to receive the track, after having been excavated to the re-

quired depth, is thoroughly rolled with a heavy steam roller, and all soft places that are thereby developed are excavated and properly filled with good, clean sand or gravel, rammed, rolled, or puddled as may be directed.

In the case of Type No. 3 track, in addition to rolling the excavation, the crushed stone is thoroughly rolled before placing the ties to receive the rails.

In designing the foundation for Types Nos. 1 and 2 track with the ties four (4) feet, center to center, it was figured that the principal office of the tie would be to hold the rails down and to line and gauge, and that the loads of passing cars would be distributed to the soil by the concrete.



Fig. 14.—Rolling Crushed Stone in the Roadway.

During the year 1907 all wood tie, concrete foundation track constructed was of Type No. 2 design with ties four (4) feet, center to center.

During the winter of 1908 the track built during the previous year was carefully inspected to ascertain its behavior under traffic, and it was found in places that a slight movement in the rail could be detected under the load of passing cars. The Chief Engineer of the Work directed that an investigation be made to ascertain the cause of the movement, to what extent it affected the track construction, and what the possible results might be.

October, 1909

In order to make this study and determine the rigidity and action of the different types of track construction under traffic, observations were taken by means of a "Deflectometer," designed especially for the purpose. (Figs. 10, 11, 12.) This apparatus was so constructed that lateral movement of the rail could be observed as well as vertical deflection, and it was also arranged so that any vertical movement of the ties in the concrete could be readily determined and measured. The principal object of the investigation was to determine if any movement occurred of sufficient magnitude tending



Fig 15.—Another Concrete Mixer at Work.

to disintegrate the concrete foundations, or to endanger the life of the track substructure. It will be observed, by an examination of the illustration that the "Deflectometer" consists of a simple lever mounted on a suitable frame, having at its outer end a pointer which moves over a scale. This lever is proportioned for a ratio of ten to one—that is—the reading on the scale is ten times the actual deflection recorded. The distance from the rail to the fulcrum being four inches, that from the fulcrum to the scale is forty inches. The frame is designed so that the joints of the supporting frame are adjustable to compensate for any inequality in the pavement, so the apparatus can be brought to a true level when the readings are being taken.

In order to segregate the vertical movement from the horizontal

movement of the rail a small clamp was made to be attached to the outer side of the rail. This clamp is placed on the under and outer surfaces and highly polished so that the point of contact with the lever will move over these surfaces without friction.

To take readings for vertical deflection the instrument was set at right angles to the track and the frame adjusted to a true level,



Fig. 17.—Electric Welding Machine

the clamp applied to the head of the rail, and the short arm brought into contact with the under surface of the clamp. (See Figure 10.) With the instrument in this position it will be seen that any vertical movement that takes place in the rail under load would be transmitted to the pointer at the scale and would be magnified ten times. In this position the instrument records only vertical movement.

To measure horizontal movement of the rail the other arm is brought into contact with the outer surface of the clamp, and in

this position any horizontal movement is transmitted to the pointer on the scale in the same manner as recording vertical movement. When in this position only horizontal movement will be recorded.

To take readings for the deflection of the tie, a longer arm was attached to the apparatus which was fastened to the tie by means of a screw eye when applied to wood ties, and when the observations were being made on steel ties the arm was hooked under the flange.

When readings were taken of the concrete substructure a small hole was drilled into the concrete and plugged with lead, and a small screw eye inserted as in the case of the wood tie.

When these tests were taken it was expected that deflection amounting to as much as from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. would be found in some places; in this, the results obtained were an agreeable surprise, for the maximum vertical deflection recorded was $\frac{5}{64}$ in. In a large percentage of the track tests no vertical deflection whatever was noted. It was also shown by these tests that greater vertical deflection occurred at the rail joints, and decreased away from the rail joints, and that the average vertical deflection observed seemed to be about $\frac{1}{32}$ in. No deflection whatever was observed in the concrete, and only in a very few cases was any deflection in the ties recorded. In these few instances the ties were excavated and it was found that the movement was due to improper tamping, leaving voids.

After numerous tests had been made it was determined that practically all movement took place between the base of the rail and the tie plate, and that, in the majority of cases, this movement was observed near the joint of the rails and disappeared entirely as the center of the rail was approached. This can be explained as follows: There is an opening left in the concrete to facilitate the welding of the joint, which is done after the concrete has been placed. When the weld is made the rail fastenings on the ties adjacent to the joint are loosened, and the rail apparently buckles when the weld is made, and, in retightening the fastenings, the rail was not forced back to its original position on the tie plates, and, when the loaded cars passed over the rail at these points the rail was forced down to the tie plate, and, after the load was removed, the rail would spring back again from the tie plate, which accounts for the vertical movement.

It should be noted that horizontal movement was recorded in practically every case of tests made. The average movement in this direction being about $\frac{1}{64}$ inch. This horizontal movement seemed to be a constant factor and varied but little in any case. These tests proved that the eye greatly exaggerated the apparent movement of the track under load. It was discovered that, even to the eye of the trained observer, the rails that seemed to have a deflection of $\frac{1}{4}$ in. in reality did not move more than $\frac{1}{64}$ in.

These tests also demonstrated that in many instances where vertical movement of the rail seemed to be observed, it was, in fact,

a horizontal movement. The tests further proved that it was impossible for the observer with the naked eye to differentiate between horizontal movement and vertical movement of the rail.

These observations proved (1) that, when the foundation is properly prepared, the concrete properly mixed and placed, and the ties properly tamped, and the concrete given a sufficient length of time to properly set before traffic is allowed upon the track, no movement occurs between the concrete and the soil or between the tie and the concrete, and that, when the fastenings are properly applied, no vertical movement will occur between the rail and the tie plate. (2) The observations proved that the types of construction that are being used in the rehabilitation of the tracks, as far as can be figured at this time, have the characteristics which promise a permanent substructure.

The rehabilitation of the properties of the Street Railway Systems of Chicago makes it possible to carry on work in the largest scale and magnitude, and will entirely change the character of the property and place it, in all departments, on a basis of most modern construction as regards cars and car houses, sub-stations, electrical equipment, track, special work, and transmission system, the latter being placed under ground in a much larger area than has ever before been attempted by any electric traction system operating by means of the over-head trolley.

The improvements now being made in the properties, together with through-routing, and the improvements in operating, including a subway through the business district, which are things we hope will be realized in the near future, will make Chicago's surface transportation equal to the best in the world.

DISCUSSION.

President Allen: Only a few years ago the Street Railway system of Chicago was an eyesore and a disgrace to any city claiming civilization. Recently, however, an experiment has been tried here which marks the beginning of a general era of improvement in matters of that kind—an era in which the street railway systems, instead of being operated solely for private gain, are operated co-operatively, the people having a share in the profits, and also controlling the details of organization, administration, and improvement. We are just beginning to find what a magnificent thing a properly built and operated railway system is. We are beginning to realize in Chicago that surface cars have a usefulness and an adaptability which no other system of transportation can ever entirely displace, and when we come back from visiting other cities we are glad, no matter what else we may miss, to get back to our own street cars and tracks which we are so fond of speaking of as the best in the world.

When this new era was inaugurated in our city, the rehabili-

tation of the existing street car systems was placed in the hands of a Board of Supervising Engineers, a body with large powers and representing all parties to the negotiations, and the speaker of the evening, Mr. George Weston, has been an active member of this Board for some years and has had a large share in its work.

H. B. Fleming, M.W.S.E.: Mr. Weston has given you the facts, figures, and some of the reasons which influenced the Board of Supervising Engineers in deciding upon plans which were finally adopted for the reconstruction of tracks in the city of Chicago, and has covered the ground in a way that I am sure will enlighten those who have had the pleasure of hearing him.

We have with us, I notice, quite a number of engineers who have been engaged in the actual work of constructing the tracks according to those plans, and I for one would be much pleased to hear them give their views regarding the plans, and to have them present some of the difficulties they encountered in the reconstruction work, which difficulties have been overcome, and in a way, very satisfactory to the Board of Supervising Engineers.

However, there is one thing I would like to call your attention to, which might be considered a construction detail, but which was given very careful consideration by the Board before the work was started; that is, the method of handling traffic while the work was being done. There are some streets where during the "peak hours" we have a minimum headway of about twenty seconds, with practically no opportunity to build track during the period of maximum traffic, or even during the middle of the day, without providing in some way for diverting this traffic. After considerable study and discussion, three general plans for handling the traffic during construction was agreed upon, and have been followed all through this work, with the result that even on a street like Wabash Avenue, where there is a minimum headway of twenty seconds, the cars actually made better time during the reconstruction of those tracks than they were able to make under normal conditions. So evidently our method of handling traffic during the reconstruction period was successful.

The first plan adopted—the simple one—was for streets where the traffic was light, and consisted of single track operation by means of turnouts and cross-over switches. The second plan consisted in the diversion of traffic to some adjacent street, which we did in some few cases where there was a trolley line less than a quarter of a mile away. We found, however, that in cases where the cars were diverted to trolley lines, even though they were only a quarter of a mile away, the receipts on that line depreciated to such an extent that we considered it advisable to follow the third plan in almost every case. This plan consists of laying what we call a temporary track, which is nothing more nor less than stringing a temporary overhead trolley and laying a third track on the street. This track being a little above the level of the street, it was free

from traffic, and so we were really able to make better running time during reconstruction than under normal conditions. I suppose most of you are acquainted with this method, because it was used only recently on Clark Street, and last year during the reconstruction of the Wabash Avenue tracks.

I am glad to have this opportunity to express my appreciation of the aid and cooperation which the city authorities have extended in all of our work of reconstruction. They have helped us in every way possible, and especially the police department in the policing of the streets. In many instances it would have been almost impossible for us to carry on the work of reconstruction if it had not been for this aid.

P. E. Green, M.W.S.E.: It is not the intention of this discussion to criticize in general the work of the Supervising Engineers, as the writer recognizes the great value of the work done by them; and the immense difficulties under which they have labored. But in some very important details, and details which will vitally affect the life of the work and its accessories, it seems to me that some advantageous modifications might be made in the designs.

In the rail section adopted, (Fig. 6 or 7) it will be noticed that the outside top edge of the head is beveled off at an angle of about thirty degrees with a horizontal plane. Just what the idea was, the writer does not know, but it probably had some connection with the paving, or possibly with the tread of the wheels. If the pavement is laid at its lower edge, it makes an ugly bump, besides having another objection in the way of drainage, which will be taken up later. This bump will have a disastrous effect on the adjoining pavement, and while Mr. Weston distinctly states that he has not taken up this phase of the traction problem, it is a matter which cannot be separated from the question. Anything that affects the impermeability of the pavement adjoining the rails, will affect the so-called permanent substructure.

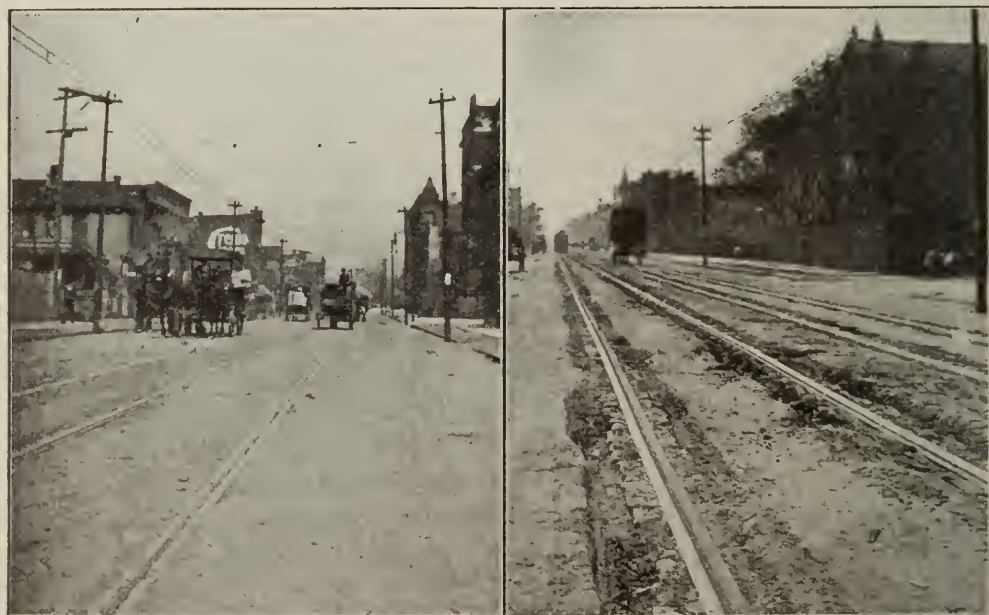
To return to the bump; a heavily loaded wagon, weighing say four tons, (and here in Chicago that is nearly a minimum for bulk loads) grinding and sliding off the rail onto the pavement will have a very considerable pounding effect, and a rut is sure to develop sooner or later. If the pavement is laid level with the top of the rail, the V shaped space left, holds water constantly, and this water lying on the track will inevitably disintegrate and destroy the pavement. After a rain, or when the street is sprinkled, this little channel of water, lying along the rail, does not evaporate at once. It cannot get away by draining across the pavement. With the most rigid construction, as Mr. Weston's paper shows, there is some vibration. The cars cause this vibration to act like a force pump on the sand bed of the pavement. The vibration, slight as it is, tends to break the bond between the granite blocks and the cement grout filler, which has been used in the construction. In a com-

paratively short time the sand bed is pumped up through the joints onto the pavement.

This is not a fanciful picture; it may be seen on nearly every street which has been reconstructed for six months. Little cones of sand, like ant-hills, may be found along the rail. As an instance of such action may be cited West Madison St. from the river to Rockwell St. This street of very heavy traffic, both of cars and other vehicles shows plainly this action. In two or three years the pavement adjoining the rail will be in bad condition.

There is one way that this action can be stopped. It is my belief that a mistake was made when cement grout was used as a filler for this brow pavement. It is not the filler for such a situation; as there is no yielding to the vibration; some of the joints will break. But as it is already in place, in order to secure a good result, a few months after the work is finished it should be gone over carefully with a sand blower, the loose joints thoroughly cleaned, and then filled with an asphaltic cement. A properly prepared asphaltic cement has a life of fifteen years, at least; it is elastic, impervious to water, and but little attacked by street liquids.

If this fault is not corrected, what effect will it have on the permanent substructure? It will be admitted that a tight, waterproof, closely laid pavement helps to keep down the vibration. This vibration, however, will never grow less, and must increase as time goes on. But if the increase is accelerated by outside influence, it will certainly reduce the life of the construction. The loosened blocks of the pavement and the grinding sand and water will tend to break up the mortar plastered under the head and against the



Taylor Street.

East of Blue Island Ave.

West of Blue Island Ave.

web of the rail, and the rail will be that much more free to pound the concrete beneath.

Taylor St., from Canal St. to Blue Island Ave., was paved with creosoted wood block in 1904. The tracks were reconstructed, but the rail section had a square edge, or one nearly so. The blocks were laid level with the rail and tight against it. After five years' service, both track and pavement are in first class condition. Lincoln Ave., paved in 1907-1908, with creosoted blocks laid close against the rail, plainly shows in many places, the effect of this bevel. Altogether, it seems to me, a very strong case may be made against the rail used.

Still more significant are the photographs, (Fig. 16) which shows the creosoted block on Taylor St., above mentioned, which is in a perfect condition to-day, and also Taylor St. from Blue Island Ave. to Paulina St., laid with asphalt *at the same time*, but with a separate granite brow. The tracks are settled about two inches, and, as may be seen, the ruts along the granite are very bad. It might be said that this is the result of the difference between the creosoted pavement and the asphalt; but the asphalt on this whole street is now in fine condition, except along the rails. The whole result is certainly caused by poor and faulty brow construction, or, in other words, the combined action of water and vibration at a point made weak by not being more nearly impervious.

It is not maintained that the reconstruction now is not better than it was in 1904, but if a creosoted wood block pavement laid tight against a rail in 1904, when the reconstruction was not as good as that of to-day, shows up better than a similar pavement laid in 1908, under more approved methods, there must be a fault somewhere, and I think it is in that apparently insignificant bevel of the rail top.

Another point is that in the reconstruction, no matter what kind of a pavement is to adjoin the rail, the concrete shoulder is made approximately seven inches below the top of the rail. This is all right where a granite block is put in, but when a creosoted wood block pavement is the street pavement, it is entirely wrong, and no variation has been made, as far as I know, in the method of construction. The specifications of the City of Chicago call for wood blocks four (4) inches in depth and on one (1) inch of sand. The granite blocks are five (5) inches deep and are on two (2) inches of sand. Thus, if the brow is built of the creosoted blocks against the rail, it is either necessary to use two to three inches of sand on the concrete already put in by the railways, or to try to put a slab of one to two inches of concrete on the concrete already in. Any engineer will recognize the difficulty of doing this last satisfactorily. But if the sand is used to bring the pavement to the grade shown on the plans (one-quarter inch below the top of the rail) the pounding of the street traffic will compress that two or three inches of sand considerably more than the one inch of sand underlying the pave-

ment laid by the City, and in a short time the pavement against the rail will be formed into a natural channel in which the water lies, to the ultimate destruction of the pavement. A good example of this may be seen on Lincoln Ave., south of Belmont. By the time the repaving of Lincoln (following the car track reconstruction) had reached Belmont, the engineer in charge realized this fault and endeavored, in the remainder of the work, to remedy it by raising the grade of the pavement slightly above the rail so that the traffic would not force it down too far. This tends, however, to bring the other fault mentioned (that of water accumulating between the rail and the block) into action, and it is somewhat doubtful if it is any improvement.

It is my belief that if the rail had been made square on that edge, the blocks would have fitted it more closely, the brooming of the edges made a better seal than the present construction, and a longer life insured for the pavement and for the permanent substructure.

Another very unfortunate matter in the reconstruction, is the placing of the special work, such as the crossings, turnouts, etc. While the specifications may state that the concrete be fourteen days old before the cars are operated over the tracks, it is a fact that at crossings and other places where this special work goes in, and where traffic is heaviest and has the most severe effect on the construction, the cars are run and the traffic is uninterrupted while the concrete is being placed; in other words, at the point of severest service, the weakest and poorest work is done. The excuse is, probably, that this cannot be helped, on account of operating necessities. It seems to me, however, that more careful planning, such as making surveys for, and ordering of, such specials in ample time, would have eliminated much of this poor work. The work of the first year may be excused, but in the third year the same condition holds. It must inevitably occur that in a very short time much of this work will become in very bad condition and will be a source of criticism and reproach to the Board of Supervising Engineers.

One of the worst features that has yet come to my notice, and which indicates faulty management somewhere, came to light recently when the Chicago Railways Company applied for a permit to lay a conduit on Lincoln Ave.; this, in spite of the fact that a new pavement costing \$200,000 has just been laid, following the reconstruction of the tracks; in fact the pavement is so new that the final estimate has not been issued. It is an absolute impossibility, in my opinion, ever to patch a block pavement and get as good a result as the original.

Another bad feature in the reconstruction work has been the breaking of the welded joints. While it can probably be demonstrated that the percentage of broken joints is very small, still with the immense number of joints to be considered, even a small percentage means quite a large number of broken joints, and every broken joint means a hole in the pavement to start the disintegration. Is

it not a question whether the old method of welding joints (that of pouring the molten metal around the joints) is not superior to the method now in use? While here in Chicago our experience with that old way was limited, still there were practically no broken joints, while now there are many.

As before stated, I do not wish to criticize the Board of Supervising Engineers for neglect of details—details which should have been met and worked out by subordinates—but such matters as the clearance between cars and the height of the car step about the street pavement are of such moment that it would seem they could and should have been satisfactorily settled before starting the work. The “death strip” is an appropriate name for the space left between passing cars under present plans. We must admit, however, that even with an ideal arrangement and operation of any railway system, some accidental fatalities must inevitably occur.

The selection of dimensions which left so small a clearance between cars was a mistake, and one which involves the responsibility for great loss of human life, and yet, what will be the result of a change at the present time as advocated by the Chief Engineer of the Board (see the “Chicago Record-Herald” of June 15th, 1909), who claims to have been overruled when he originally recommended a greater clearance? It has been argued in this connection that people once knowing that there was no escape for him who was caught between cars would keep the fact in mind and guard against such danger. If, now as the reconstruction work is over half done, a change is made, how confusing it will be for one not yet versed in mathematics to figure his chances of life in an emergency when he remembers that in some places there are but eight and one-half inches, while in others there are twenty inches between cars. Again, the special work which must be all or nearly all ordered, would be a source of annoyance, to say nothing of expense, and while it may have been satisfactorily demonstrated to the Board of Supervising Engineers that a rail with its base embedded two inches deep in concrete can be removed easily and replaced by a new rail. I am very skeptical about the practicability or economy of trimming out a new bed for the rails in the “permanent concrete substructure,” when it is desired to put new rails in a different location for the old ones.

In closing, I wish to thank my friend and colleague, Mr. William W. Marr, M. Am. Soc. C. E., for many suggestions in connection with this discussion and for the photographs which illustrate the text.

E. N. Layfield, M.W.S.E.: I think it might be interesting if some one would tell us something about the electric welding process.

R. F. Këlker, Jr., M.W.S.E.: We obtain the electric power for welding from the trolley wire at about 500 volts D. C. and transform it to about 300 volts A. C., by means of a rotary converter in one of the welding cars, and this alternating current is conveyed

See Fig. 17, Page 589, for illustration.

to a second transformer placed in the center of the welding jaws, which again steps down the voltage, until we have about 5 volts, with the amperage running above 30,000. A bar is placed on either side of the rail web and they are joined to the web by these electric welds. The first weld, which is made at the junction of the rails, (the joint having previously been shimmed tightly) is an ellipse in shape, and its long axis is vertical. The object of making the first weld at the center is to get the maximum elongation of the bars through heat, and then, after the end welds are made, and the bars become cool, a contraction takes place, which gives a pull at the joint, draws the rail ends together, and gives the effect of a clamp. In making each weld, after the proper temperature is had, which is determined by the eye of the foreman, pressure is applied by means of an hydraulic jack set in the welder jaws, and the weld is compressed in order to work the metal, and obtain a better grain than would result from the simple application of heat.

Mr. Green, in his discussion, remarked that the percentage of failures of joints was probably higher than that due to the older form of welding, or the cast weld. If I am correctly informed, I think Chicago, Milwaukee, and Minneapolis have had the greatest success with cast welding of any cities. In the East cast welding was tried at various times but not with great success, owing to two facts: First, the slipping of one of the rails in the body of the metal cast around the joint, and second, the pounding of the head of the rail under traffic either at the joint itself or immediately adjacent at the end of the cast weld itself, which results in poor surface. Although I might be criticized for saying so, I believe electric welding is superior to cast welding, particularly when applied on rails of 7 in. or more in height; the Standard Chicago rail, described by Mr. Weston, is 9 in. in height.

Mr. Layfield: I would ask whether any distinction is made in the welding process due to the temperature of the atmosphere. In splicing rails for steam railroad, where they are not welded, a greater space is left at the joints in cold weather than in hot weather. The welded rails, if laid in hot weather, would have a greater temperature stress in cold weather than if they were laid in cold weather. Is this recognized in the welding process, or is the process exactly the same, regardless of temperature of the atmosphere,

Mr. Kelker: In the comparison of surface tracks with steam tracks, we have one important fact to consider, and that is the amount of metal exposed to the action of atmospheric temperature, is comparatively small. The rail being embedded, we have not the hot rail we find on a steam road. In the work here we have paid no attention to the expansion of the rails, knowing that the pavement and rail fastenings would keep the rails from buckling. One thing I have observed in regard to the expansion is that the strains in the rail are apparently local.

In New York City, on the underground electric railway, they had

considerable trouble in hot weather from the movement of cast welded rails. It has been to such an extent that it forced the "slot" to close, in some instances, so as to bind the "plow" or underground trolley and stop operation. This would be corrected by taking a fire hose and wetting down the street intersection.

In New York City the best success with cast welding was had where the work was done at night and during the cool season of the year. They have had considerable trouble with expansion joints which their engineers believed necessary to use.

Mr. Layfield: Do you conduct the work just the same in summer as in winter?

Mr. Kelker: As no allowance is made for expansion and contraction, the matter of different seasons is not considered.

President Allen: How is the joint assembled before welding?

Mr. Kelker: The rails are first butted together and held by temporary splice bars during construction. The first operation is to remove the temporary splice bars and then sand-blast the rail as well as the weld bars at the points of contact. The bars are $1\frac{1}{8}$ in. thick, $3\frac{1}{2}$ in. broad, and 22 in. long. They are placed in position on small brass chucks which will hold them to proper height (the joint having been shimmed by a thin section of the rail), and the welds are made in the order previously stated. After the welding is completed, a grinding machine is used to remove any inequality in the head of the rail, and brings it to a true and finished surface.

There has been considerable improvement in the manipulation of the welding process since the work began in Chicago. We had more trouble the first season than we had expected, but we now have a better weld and a marked decrease in the percentage of breakages. This improvement was the result of a series of experiments made by the contractors.

President Allen: How do the breakages in the electric weld joint, such as you are installing at the present time, compare with the best examples of cast joints?

Mr. Kelker: I would say, off-hand, that our highest breakage has been 50% less than the ordinary breakage of cast welded joints. In other words, if we had 5% breakage in electric welded joints, in the same work there would have been 10% or higher in the cast welded joints.

President Allen: What length of rail are you using?

Mr. Kelker: The rails we are installing are 56 and 58 feet long.

C. R. Dart, M.W.S.E.: It seems to me that the area of the splice is much less than the area of the rail, and I should think there must be a variation in temperature of rails of at least 80 degrees between summer and winter, producing considerable stress on the rails. It also seems to me that the area of the weld is less than the area of the spliced rail.

Mr. Kelker: With one or two exceptions no joints failed to

show the 100% in conductivity required, and the majority showed considerably over that amount.

Mr. Weston: The majority of breaks—over 90% of them—are outside of the bar and the portion that is welded.

In experimenting with the weld at the testing plant of the Rail Joint Company, after the first year's use of the electrically welded joint in Chicago, in order to improve the character of the weld, there was a great many sections of rails welded and tested with a testing machine, and in almost every instance the rail would break outside of the welded bar, indicating that the rail at the joint is stronger than the rail section itself. These tests also developed the fact that the use of flux improved the joint.

Mr. Kelker: It is a rare instance when you get a break through both bars.

Mr. Sawyer: Does it ever occur that the weld itself breaks—that the bar breaks loose from the rails?

Mr. Kelker: I have never known that to happen.

President Allen: From the standpoint of a structural engineer, I think we should find some weaknesses in the joint. I suppose, however, "the proof of the pudding is in the eating." What experiments were made to determine the life of untreated timber embedded in concrete? Was that determined from data at hand or what evidence did you have to come to your conclusions?

Mr. Weston: I presume all of the members of the Board (I know I did, myself) resorted to all the literature they could find on the subject. We applied to the Division of Forestry at Washington and were flooded with literature on the subject of treatment of timber for the purpose of preservation. I think we nearly exhausted all the points they had to offer. In addition to that we had the aid and advice of Mr. Samuel Rowe, who has spent years in the study of the preservation of timber, particularly in regard to the preservation of ties on steam railroads; also had the advice of Mr. Octave Chanute, who gave us a long discussion of the advantages, etc., of the different methods of preservation of tie timber. We have in our files a package of literature leading up to the final conclusions by the Board, that I should be very glad to turn over to anybody who wishes to go into the subject. But I do not think it would be wise to take time this evening to go further into this matter.

We consider the advice received from Mr. Rowe and Mr. Chanute as important as any we had on the subject, and as a result of our study and discussion, and the information we have received from the gentlemen referred to and others, we concluded, that the chloride of zinc treatment was best suited for our purposes, and would preserve the ties against decay.

S. H. Goodenough: I will make a few comments on Mr. Green's criticism of the method of installing special work. He makes the statement that two weeks' time is required to allow the concrete to

set sufficiently to stand traffic. That is true only of Type No. 2 and Type No. 2-A tracks. The special work is all practically Type No. 3 track and is, to all intents and purposes, as far as the question of track is concerned, a completed track before the concrete is put in at all, the concrete merely serving to form a foundation for the paving and protect the ties from moisture. Of course it doubtless helps the life of the work to have that concrete tamped well under the rail, but the prime object of the concrete in this type of track is to support the pavement. Also having traffic on that work while it is being put in, serves the purpose of the steam roller on the straight track work, and tends to settle the sub-grade and the ballast prior to the time the work is finally closed, so we have a chance, after the traffic has been on the work several days, to give it a final lift and tamping before the concrete is put in and the street closed.

Mr. Green suggested that the special work should be secured in advance and put in at the same time as the straight track-work. In a few instances we tried that, and I believe it was found not to work out to any particular advantage. In the first place the curves which are being placed are frequently almost indispensable to the straight track construction gangs for the purpose of getting the material on the streets. If we tear the curves up, we are greatly hampered by the loss of those curves.

Mr. Layfield: I think it would be of a good deal of interest if some of the gentlemen present would give us some information in regard to the progress of the work—for instance, how long it takes to complete a block, or how great a stretch of track can be completed in a certain number of days.

Mr. Dart: I was much impressed with the results of the tests, in view of the great difficulty usually experienced in obtaining true steel castings of this character. I would like to inquire as to what percentage of castings were rejected.

Mr. Weston: In regard to the solid manganese castings. We have had considerable trouble and complaint from the "special" work manufacturers about making perfect castings, preventing warp and other serious defects in casting the large solid crossings. I will say, however, that we have succeeded up to the present time in eventually receiving all the special work layouts complete that the manufacturers have contracted to deliver, and they have passed the inspection of our representatives at the works. I could not say what percentage of castings are rejected, because a large part of the rejected castings never reached our Inspector. While at one factory, where a large part of our work has been built they showed us their junk pile, which was largely made up of manganese castings. Upon inquiry we learned that out of the total number of rejected castings, only three or four pieces had been put up to our Inspector for his inspection. The other pieces were no doubt rejected beyond question and as they came out of the mould the manufacturers decided that they would not do and threw them out on

the scrap heap without any hesitation. These are some of the difficulties that are encountered in an endeavor to use the manganese steel solid castings. These difficulties I presume were all appreciated by the manufacturers and largely anticipated. While there has been some criticism of the severity of our specifications, we have had little trouble, and we are getting our work.

President Allen: Is there any appreciable difference in the riding qualities of Type No. 1 or 2 track as against Type No. 3? I understand that Nos. 1 and 2 tracks are on a solid concrete base, and No. 3 track rests on rolled stone.

Mr. Weston: Mr. Fleming is the Chief Engineer of one of our largest roads, and I think if there has been any preference shown for any one style by the operating men, he may have heard of it.

Mr. Fleming: Sometime ago we had that question up for discussion at one of our meetings. At the conclusion of the discussion they took a vote on the question, which resulted in a tie, and they wanted me to decide it. That is about where the matter stands.

Hugo Schmidt, M.W.S.E.: At the time the matter of joints was being discussed, I wanted to ask whether, when breakages occur due to expansion or contraction, the breakage extends into the concrete? As I look at it, the concrete adheres for the entire length of the rail to that portion of the rail which is embedded in it, and any movement of the rail at one point, if there is a break, must affect in some way or another, the concrete.

Mr. Kelker: We have never known of any such breaks. I do not believe the bond between the rail and the concrete is sufficient to resist the horizontal movement of the rail. There has been no fracture in the concrete along with the fracture of the rail, to my knowledge.

President Allen: Mr. Green has raised a question in regard to the 30 degree bevel on the edge of the rail head. Could Mr. Weston or Mr. Fleming tell us anything about that?

Mr. Weston: I should judge, from Mr. Green's remarks, that he is interested, principally, in the question of paving, and, as he correctly stated, paving is an important question in connection with track-work. But, as was set forth in my paper, I believe that the subject of paving is of sufficient importance to make it a separate subject aside from track-work, and in addition the pavement can be macadam, brick, creosoted block, or any of the various types of pavement, and not at all affect the type of track. That is why the subject of paving was not taken up in connection with this paper.

In regard to the small bevel that has been criticised, I presume, from Mr. Green's point of view, it is a proper criticism. The rail was designed to accomplish two things: First, to comply with the requirements of the City Ordinances, which specify a grooved rail. In the second place we have endeavored to design the rail so that it would fill, as completely as possible, the office for which it is put into the street; namely, carry the cars and afford a negative return

for the electric current. We also endeavored to design a rail that would give as long a life as possible under the operating conditions. The subject of the life of a rail was a question which it was necessary to go into quite thoroughly at the time of the valuation of the street railway properties, in connection with the passage of the Ordinances of February 11, 1907, and was discussed and argued by three eminent engineers—namely, Messrs. M. E. Cooley, H. B. de Pont, and B. J. Arnold, who were assisted by the minor lights that were fortunate enough to have a part in the discussion.

The life of a rail was figured from the following premise: that a rail was considered to be worn out when the head had been worn down to the point where the flange of the wheel (which is $\frac{5}{8}$ in.) would bear on the bottom of the groove, when a grooved rail was used, or on the wagon tread of the rail, when a "tram" rail was used. And this amount of wear was considered the wearing life in the valuation work of the properties. This offered a definite rule for actually measuring the rail depreciation (neglecting the joint) instead of going out on the street and saying, "I guess this is 50% and that 25%," etc. The joint depreciation was treated separately. If the rail was in perfect condition at the joint, and in every other way perfect, then the depreciation was figured from the amount of wearing life left in the rail, which was the amount that was left after deducting $\frac{5}{8}$ in. from the total height of the head, measured from the bottom of the groove or from the tram.

In designing this new rail, we endeavored to get as much wearing life as we could in the head, and at the same time have a rail that would be practical, as far as the depth of the groove was concerned and other conditions that would affect the ordinary vehicular traffic on the street. Consequently the height of the head is $1\frac{1}{4}$ in. from the bottom of the groove to the top of the rail, which, I might say, corresponds to the average height of all the modern street railroad rails which have been designated, rolled, and are in use today.

In regard to the small bevel on the back of the rail which has been criticised, I will say that, from Mr. Green's point of view, his criticism is probably well taken, but our plan does not show the pavement outside of the rail to be above the bevel and if the pavement is placed as directed, no groove would exist to collect water. One reason for having the head of the rail a little above the pavement was to create a condition that would as much as possible keep the head of the rail clean. In connection with electric operation, it is very important to have a clean rail. Another reason is that the brow pavement very often comes up. A slightly raised rail prevents the wheel tread from coming in contact with the brow paving which, through frost and other conditions, is lifted up.

In designing this rail we used all the knowledge and applied all the science that we could command in connection with the subject, and I believe, for a grooved type of rail, the design adopted is a good one.

There is another point about raising the rail up that I might mention. A study of the question will show that the groove guard is a little below the top or head, of the present rail. We kept the rail up a little so that the average of the rail and the pavement and all the street conditions would be practically level as the head wears away.

In regard to the failure of the pavement along the rail, and Mr. Green's statement that it might be seen on nearly every street, exaggerates the facts. Failures have occurred in a number of instances, but the great *majority* of pavement has stood up. Our specification for the character of the block, the manufacture, the parallel sides, and everything that pertains to procure a perfect paving-block is an exact copy of the City's specification, issued by the Board of Local Improvements, (except that there is a little variation in the width and length) even to the chemical analysis for the paving pitch. This was done to insure the pavement in the tracks being equally as good as the pavement laid by the City. In endeavoring to get the blocks manufactured, we found that it was a difficult thing to conform to the specifications, and I think Mr. Green will agree with me that it is an utter impossibility to live up to specifications as regards manufacture of paving blocks.

We put Inspectors in the field at the quarries and we believe we are getting the best blocks that are manufactured. I do not think the city inspects its blocks before delivery. We found it necessary to determine what would be a reasonable interpretation of the specifications of the City, covering the manufacture of granite blocks. We could not get paving blocks if we demanded exactly parallel facing, and were obliged to allow an undercut to the stone. The City is getting exactly the same kind of stone, or worse as they do not inspect it at the quarry. We lay our paving as well as it can be laid, but we find this—that it is impossible, with the character of stone and specification requirement for laying the stone, to sweep the joints full of gravel or otherwise to fill the voids with hot pitch. There is a void left in the stone not filled, and the result is water gets underneath the block and the vibration causes the sand and water to churn up, when little bubbles of air will be observed. Mr. Green can see the operations on Wabash Avenue, removing the brow in places where this condition exists, and we are endeavoring to correct it by placing the brow stone on cement grout instead of sand. In place of pouring tar, as provided by the City specifications, we are using Portland cement grout to fill the voids, and I believe that if we were permitted to do it, although the ordinance specifies tar, we should be very glad to use a cement grout for all our pavement instead of tar.

Mr. Green: It is that outside grout pavement, it seems to me, which is the most serious objection to the paving. That is where I claim it would be better to use the tar or asphalt.

Mr. Weston: The result of our observation has been that where

we have set the brow block in the cement, in the 1:2:3 sand, and have grout or brow on the outside, it stands, but where we have not done that, we have failed. Mr. Green's suggestion to use asphalt cement instead of tar or grout may have merit and will be considered. But as I said a few moments ago, I do not believe it would be well for me to discuss here, in advance, a subject that is to come up before the Board.

I agree heartily with Mr. Green that asphalt pavement has no place in a street where there are to be street car tracks.

In regard to the "special" work, Mr. Goodenough mentioned the practical points in connection with the disadvantages of endeavoring to place the special work along with straight track work; it is practically impossible, for considering the magnitude of the work, we would never get done.

Mr. Green made the criticism that we have not the plans ready and the special work all on the ground in advance. I wish to say that we have been delayed, probably, more by the Board of Local Improvements in connection with the matter, than any other source, for the reason that we wish to work with them. It is likely they have acted with us as promptly as they could, but it is necessary for us to conduct the rehabilitation of our tracks in the streets at the same time they are carrying on their paving. For instance, we would decide that we would start first on such and such a street. This schedule has been made up in January and February. We could not survey our special work until we knew what tracks were to be rehabilitated, and we could not make our plans until we had all the information.

In regard to the criticism about the centering between tracks, that is another question which I do not care to discuss just now. I will say, however, that the present center between tracks is the standard of the Board, as agreed upon unanimously in the beginning of this work. There have been differences of opinion that have arisen since, and the subject is now under discussion.

I am glad that Mr. Green made his criticisms for that is the object of this paper.

Mr. Gableman: I want to correct one statement that Mr. Weston made in regard to being delayed by the Board of Local Improvements, I think he is mistaken in that.

Mr. Weston: My statement about delay refers to our waiting for information from the Board of Local Improvements regarding the streets they intend to pave, and after receiving this information, we endeavor to make our rehabilitation program fit the Board of Local Improvement's schedule. I will ask Mr. Fleming to say something along this line.

Mr. Fleming: It is our aim, in conducting the work of rehabilitation, to cooperate with the Board of Local Improvements, and I think that on the South Side we have been able to get our work done sufficiently in advance to permit the contractors to go ahead

with their contracts without any delay. There are several streets which this Board has asked us to do two years ago on which we completed our work as per request. The contractors have not started yet. I think Mr. Green will bear witness that the Chicago Railways Company has kept ahead of the Board of Local Improvements, and that we have now more streets finished on the South Side than we were expected to do this year.

Mr. Ritchie: I notice that the Board of Supervising Engineers decided in favor of wood ties, in tracks 2 and 3, and steel ties in track 1. It seems that later on they were troubled about the deflection, and they found that the deflection was something like 1/16 in. I do not see the advantage of using wood ties under those circumstances.

Mr. Weston: I do not see any particular connection between the deflection in the track and the cushion effect. Wood we know has the ability to absorb shock, but I do not think one need necessarily follow the other. For instance, with the steel tie, where you would not expect any cushion effect, you might have a deflection of the track. I do not wish to combine the two. One thing we wish to avoid is deflection.

Mr. Green: On the No. 3 type of track, what is the use of putting in concrete at all? In other words, why should not crushed stone be better than concrete?

Mr. Weston: We put the concrete in between the ties and on top as a foundation for the paving, for the reason that the use of a little cement and sand is a good thing. That is why we put it in, simply to make a paving foundation. We do not depend on that for the life of our track at all.

Mr. Kelker: In regard to the progress of the work—ordinarily one gang laid one-half mile of track a week. We are now laying a little more than three and one-half miles per week on the North and West Side properties.

SEVENTEENTH NATIONAL IRRIGATION CONGRESS

"SPOKANE, WASHINGTON, June 2, 1909.

Western Society of Engineers, Chicago, Ill.

GENTLEMEN: The seventeenth National Irrigation Congress meets in Spokane August 9-14 next, for the consideration of and action on irrigation, drainage, forestry, deep waterways, good roads, and home-building.

The conservation of our natural resources is the most important question before the American people today. Of the National Irrigation Congress, Theodore Roosevelt said: 'This Congress undoubtedly is one of the most important unofficial bodies in the country.' It is of as great importance to the people of your state as to any other.

It is our earnest desire that you be here to take part in our deliberations, and carry back to your people the messages of importance which the National Irrigation Congress will have for them. It gives us great pleasure, on behalf of the Board of Control, to extend to you, and through you to the members of your staff, a most cordial invitation to attend the seventeenth National Irrigation Congress.

We will feel highly honored by the presence of yourself and other representatives of your publication. Will you kindly advise us at your earliest convenience of your acceptance of this invitation.

Respectfully,

(Signed) ARTHUR HOOKER,

Secretary, Board of Control, National Irrigation Congress."

SPOKANE, WASHINGTON, June———. Regarding the importance of the work of the National Irrigation Congress, which will have its seventeenth session in Spokane, August 9-14, R. Insinger, Chairman of the Board of Control, says:

"The National reclamation act was passed in 1902. At that time there were in the government's name, in the sixteen states affected, 600,000,000 acres of arid land, of which it was estimated possible to reclaim sufficient to support 50,000,000 people. By 1911 the Reclamation Service will have reclaimed nearly 2,000,000 acres at an estimated cost of \$70,000,000. There are 40,000,000 acres of arid lands susceptible to reclamation by irrigation. The construction cost of the reclamation works is returned to the government from the sale of land, the proceeds to be again used in furthering irrigation development. Irrigation is making a garden spot and an empire of the 'Great American Desert,' and the work of the irrigation congress is yet in its infancy.

"George E. Barstow, of Barstow, Texas, is president of the congress; B. A. Fowler, Phoenix, Arizona, secretary; R. Insinger, Spokane, chairman of the Board of Control; and Arthur Hooker, Spokane, secretary of the Board of Control."

"CHICAGO, June 7, 1909.

Mr. Arthur Hooker, Sec'y, Board of Control, National Irrigation Congress, Spokane, Wash.

DEAR SIR: Accept our thanks for your notice of the seventeenth National Irrigation Congress, to be held in Spokane in August.

This will be laid before the Board of Direction of this Society at their next meeting. If we can do so, a delegate will be appointed to represent this Society at your Congress.

With thanks for your courtesy, I am Very truly yours,
(Signed) J. H. WARDER, *Secretary.*"

"CHICAGO, ILLINOIS, August 2, 1909.

Mr. Geo. L. Sawyer, Northwestern Engineering Corporation, Lindell Block, Spokane, Wash.

DEAR SIR: The Western Society of Engineers has been invited by the secretary of the Board of Control of the National Irrigation Congress, which meets in Spokane August 9-14 inclusive, to be represented at that Congress. The president of this Society, Mr. Andrews Allen, desires me to invite you to act as such representative. We earnestly hope that your business engagements will permit you to accept this appointment, and that we may have a reply from you at your early convenience to that effect.

Trusting that I may hear from you in the very near future I remain
Very truly yours,

(Signed) J. H. WARDER, *Secretary.*"

"SPOKANE, WASHINGTON, August 5, 1909.

Western Society of Engineers, Chicago, Illinois.

GENTLEMEN: Replying to your kind favor of the 2nd, I would say that I shall be only too pleased to act as the representative or delegate of the Western Society of Engineers at the National Irrigation Congress to be held in this city. While I am not informed in detail as to the organization of the congress, yet I believe that the Western Society of Engineers will be entitled to a certain number of delegates and votes. If I can be of any service to the 'Western Society' in this matter, or in any other matter, you may be sure that the service will be only too gladly rendered.

With best wishes for the society, I am Very truly yours,
(Signed) GEO. L. SAWYER."

"CHICAGO, August 9, 1909.

Mr. George L. Sawyer, 410 Lindelle Block, Spokane, Wash.

DEAR SIR: Your letter of August 5th received this morning. I have sent the following telegrams which I hope will be delivered promptly:

'George L. Sawyer, Spokane, Wash.

Thanks for letter. Have wired Secretary Hooker, of Irrigation Congress, that you will represent the Western Society of Engineers.'
'Arthur Hooker, Sec'y, Board of Control, Spokane, Wash.

The Western Society of Engineers, Chicago, will be represented at your congress by George L. Sawyer, of Spokane.'

When the congress has adjourned, will you kindly make a report to this society as to what was done, etc. Also please return the papers sent you in our letter of August 2nd.

With thanks for your services in this matter, I am

Very truly yours,

(Signed) J. H. WARDER, *Secretary.*"

"SPOKANE, WASHINGTON, August 18, 1909.

Western Society of Engineers, 1735 Monadnock Block, Chicago, Illinois.

GENTLEMEN: In compliance with the request of the secretary, I accepted your appointment as delegate to the seventeenth National Irrigation Congress, which was held in the city of Spokane from August 9th to 13th inclusive, and in accepting that appointment I had assumed that I would be able to attend most of the sessions. Unfortunately I was called from the city for the first three and a half days of the convention, so that I was in attendance but a day and a half.

While it would naturally be assumed that the congress was called primarily for the purpose of considering irrigation and kindred subjects, yet the convention soon resolved itself into a controversy between the supporters of Secretary of the Interior, Richard A. Balingier, and the supporters of United States Forester, Gifford Pinchot. There is undoubtedly plenty of room for argument on either side, at the same time the majority of the delegates are more interested in the smaller problems which are presented in the development of the resources of the West. Similar controversies occur every year, but thus far the people of the West have not derived any great benefits from the discussions themselves.

Reports from the arid states, and especially from Idaho, showed a most remarkable development. Since the passage of the Carey Act over ten years ago, southern Idaho has witnessed a development through reclamation that is second to no other state. The government reclamation service reported the expenditure of \$50,000,000 throughout the West, since the creation of that department. While many were inclined to criticise the reclamation service for having distributed this large sum over too large a field, yet they are already beginning to show the returns.

The consideration of waterways was one of the most interesting topics before the congress, for it was evident, from the addresses and discussions, that this feature of the development of our country has received but a small part of the deliberation that it deserves. All of the speakers on this subject urged the active cooperation of all in an effort to thoroughly arouse the national government to make the necessary appropriations for the opening to navigation of the large waterways, and I believe that the most urgent plea that the Irrigation Congress would make to the Western Society of Engineers

would be that the latter use all the influence that they can command, both as a society and as individuals, to "boost" for the "open-river."

The eighteenth National Irrigation Congress is to be held in Pueblo, Colorado, and it is hoped that every member of the Western Society of Engineers who can attend will be on hand. As soon as the proceedings of the last congress are published, I will send copies to the society.

With best wishes for the society, and thanking you for the honor you conferred upon me, I am

Very truly yours,
(Signed) GEO. L. SAWYER."

THE RENSSELAER POLYTECHNIC INSTITUTE

Of interest to many members of the Western Society of Engineers, is the occasion of the formal opening of the Russell Sage Laboratory of the Rensselaer Polytechnic Institute which took place in Troy, New York, on June 15th, 1909.

This Institution, the oldest of American Engineering Schools, was founded by Stephen van Rensselaer in 1823, and until 1905, had been maintained practically by the tuition fees of the students, and occasional help from loyal graduates and the citizens of Troy. In that year loss, by fire, of the main building of the Institute, threatened discontinuation of the school, as the Institute had long felt keenly the competition of the larger and more completely endowed and equipped technical colleges.

When this fact became known, the alumni and the residents of Troy succeeded in raising a sum, which, with the insurance money, made possible the purchase of new grounds, and the building of a chemical and assaying laboratory. It remained, however, for Captain R. W. Hunt member of the Western Society of Engineers, who has always taken a great interest in Rensselaer, to secure from Andrew Carnegie a donation sufficient to erect a large and fully equipped building for general instruction. This assistance enabled the Institute to more than regain its former prestige, and then came the gift of one million dollars from Mrs. Russell Sage, which is noteworthy among endowments and gifts to educational institutions from the fact that absolutely no conditions were attached to it.

Mr. Sage was a member of the board of trustees of the Institute for some years, and his nephew, Russell Sage II, was graduated from there in 1859.

A portion of Mrs. Sage's gift has been expended in the construction of a complete physical and chemical laboratory, which bears Mr. Sage's name, the remainder put into an endowment fund for its support, and has been the means of adding to the curriculum two courses, leading respectively to the degrees of Mechanical and Electrical Engineering.

Thus it is that "Old Rensselaer" again takes rank among the foremost Engineering Schools of America.

G. T. H.

PROCEEDINGS OF THE SOCIETY

MINUTES OF THE MEETINGS

REGULAR MEETING, September 1, 1909.

A regular meeting of the Society (No. 668) was held Wednesday evening, September 1, 1909.

The meeting was called to order at 8:20 P. M. with President Allen in the chair, and about 80 members and guests present. The minutes of the meetings held June 2d and June 16th were read and approved.

The Secretary reported from the Board of Direction the election into the Society of the following, at the meeting of July 1:

No. 43.	Howard M. Raymond, Chicago.....	Active
" 44.	Bernard R. McBride, Madison, Wis.....	Junior
" 45.	Tom R. Wyles, Chicago.....	Associate
" 46.	Fred A. Sager, Chicago.....	Active
" 47.	W. A. Dorcas, Chicago.....	Associate
" 48.	Albert E. Clearman, Chicago.....	Active
" 49.	Frank A. Newton, Madison, Wis.....	Junior
" 51.	J. H. Heuser, Chicago.....	Active
" 52.	Samuel T. Smetters, Chicago.....	Active

At the meeting of August 3rd:

No. 53.	William A. Bennett, Chicago.....	Active
" 54.	George E. Pfisterer, Chicago.....	Junior
" 55.	George Schobinger, Chicago.....	Junior
" 56.	Paul Hodges, Monroe, Wis.....	Junior

At the meeting of August 31st:

No. 42.	Rudolph G. Rosenbach, Chicago.....	Active
" 57.	Lawrence N. Jackson, Greenville, Ohio.....	Active

The Secretary presented the following petition for the first reading:

To the Membership of the Western Society of Engineers:

With the object of improving and making clear certain parts of the Constitution and By-Laws of the Society, some amendments have been prepared by the Committee on Amendments. These were submitted to the Board of Direction at its meeting held August 31st and were approved, and are now presented to the Society in due form by petition, as provided for in the Constitution and By-Laws.

The object of the amendments to the Constitution, Article V, and to the By-Laws, Articles I, II, and III, is to have more time between the close of the year and the Annual Meeting and to give some days' interval between the election of the new officers and the Annual Meeting when they assume office, and to provide for a regular meeting of the Board of Direction for finishing the business of the past year and receiving the election returns.

The object of the amendments to Article VI of the By-Laws is to confirm, as a part of our organic law, the practice of the Board of Direction, during recent years, of remitting dues of members of over thirty (30) years standing.

AMENDMENT TO THE CONSTITUTION.

ARTICLE V.

ANNUAL MEETINGS.

Section 1. The Annual meeting shall be held on the first Wednesday after the first Thursday in January. at which the results of the election of Officers of the Society shall be announced, the Annual Reports received, and other business may be transacted.

AMENDMENTS TO THE BY-LAWS.

ARTICLE I.

Section 1. Omit everything after the word "quorum" so that the Section shall read "At the Annual Meeting of the Society twenty-five (25) Active members shall constitute a quorum."

ARTICLE II.

Section 8. Substitute "three (3) weeks" for "ten (10) days" where it occurs in the first line of this Section.

Section 10. Substitute "the Friday next before" in place of "the day of," where these words occur in the first line of this Section.

Section 12. Substitute "presented to the Board of Direction" for "handed to the President," where this word occurs in the last line of this Section.

ARTICLE III.

Section 2. Add the following paragraph after the fourth paragraph of this Article: "The Board of Direction shall meet on the day fixed for closing of the polls, to receive and canvass the report of the Judges of Election and to transact such other business as may come before it."

ARTICLE VI.

Section 7. Substitute for the entire Section: "The Board of Direction may, for good reason assigned, temporarily excuse any member from payment of annual dues, and said Board may remit the whole or part of dues in arrears or accept in lieu thereof desirable additions to the property of the Society."

Section 8. Substitute for the entire Section: "Every person admitted to the Society shall be considered a member thereof and shall be liable for the payment of all dues except he shall have resigned, been expelled, or have been relieved from payment of said dues by the Board of Direction or by the provisions of these By-Laws."

Amend by adding another Section, as follows:

Section 9. Active members over sixty (60) years of age shall cease to pay dues after thirty (30) years of continuous membership.

We, the undersigned Active members of the Society, respectfully petition that amendments be made to the Constitution and By-Laws, in accordance with the above:

(Signed)

ANDREWS ALLEN
W. L. ABBOTT
C. F. LOWETH
P. JUNKERSFELD
O. P. CHAMBERLAIN
ALBERT REICHMANN
W. C. ARMSTRONG
E. E. R. TRATMAN
KEMPSTER B. MILLER
J. M. WITHERSPOON
JULIUS FLOTO
CHAS. L. STROBEL
H. M. MORSE
W. E. ANGER.

There being no other business to come before the Society, the President introduced Mr. Willis McKee, of Elyria, Ohio, who presented his paper on "The Rolling of Special Sections of Iron and Steel," with lantern slide illustrations.

Discussion followed from President Allen and Messrs. James E. Jones, G. F. Dodge, S. T. Smetters, O. P. Chamberlain, G. T. Bunker, J. H. Heuser, G. M. Mayer and G. W. Brady.

The meeting adjourned about 10 P. M., when refreshments and cigars were served.

EXTRA MEETING, September 15, 1909.

An extra meeting of the Society (No. 669) was held in the Society Rooms Wednesday evening, September 15, 1909.

The meeting was called to order about 8:25 P. M., with President Allen in the chair and about 75 members and guests present.

As there was no other business to bring before the Society, Mr. John M. Ewen, M.W.S.E., was introduced, who presented his paper on "The Chicago Harbor." In the course of his address the speaker urged that the Society be represented by a committee, to be in attendance at the public hearings when this subject will be considered by the City Council, or a committee of the same, to give the movement the moral support of their presence, and perhaps to offer explanations or arguments in favor of any action taken to create a harbor for Chicago.

A resolution was offered that a committee be appointed by the President to represent the Western Society of Engineers to confer with the committees of the City Council, and others, in regard to plans for the development of a harbor for Chicago, and to report progress, from time to time, to the Society.

After some little discussion and explanations, the resolution was voted on and carried.

The paper of the evening was discussed by Messrs. J. W. Mabb's, R. P. Morgan (by letter), R. J. Mershon, G. A. M. Liljencrantz, C. F. Loweth, J. C. Bley, Isham Randolph, R. C. Huston, H. J. Fixmer, and the author.

The Secretary announced the death of our member Mr. C. W. Birch-Nord, September 15, 1909.

The meeting adjourned about 10:50 P. M.

REGULAR MEETING, October 6, 1909.

A regular meeting of the Society (No. 670) was held Wednesday evening, October 6, 1909.

The meeting was called to order about 8.20 P. M. with President Allen in the chair and about 70 members and guests present.

The minutes of the meetings of September 1st and 15th were read and approved. The Secretary reported from the Board of Direction the election into the Society of the following:

No. 58, Roy H. Deakman, Chicago.....	Junior
No. 60, Wm. W. Sayers, Chicago.....	Active
No. 61, W. M. Vandersluis, Chicago.....	Junior
No. 62, F. W. Dencer, Chicago.....	Active
No. 64, Addison A. Righter, Chicago.....	Active

Also that the following had applied for membership:

No. 65, Hugo Arnold, Chicago	Active
No. 66, R. C. Mitchell, Chicago.....	Transfer from Junior to Active
No. 67, William F. Martin, Chicago.....	Active
No. 68, Julian B. Freeman, Chicago.....	Junior

The President then introduced Mr. C. T. Barnum, of the Forest Service U. S. Department of Agriculture, Washington, D. C., who read his paper on "Wood Preservation from an Engineering Point of View." Discussion followed from Messrs. Andrews Allen, O. Chanute, D. W. Roper, W. W. Curtis, Theo. Kandeler, L. J. Hotchkiss, C. F. Loweth, and the author.

Mr. O. P. Chamberlain offered a motion that a vote of thanks be extended from the Society to Mr. Barnum, which was carried.

The meeting adjourned about 10:20 P. M.

October, 1909

EXTRA MEETING, October 20, 1909.

An extra meeting of the Society (No. 671) was held Wednesday, October 20, 1909.

The meeting was called to order at 8.20 P. M. with President Allen in the chair and fully 150 members and guests present, though the weather was rather inclement.

There was no business before the meeting; in Mr. Allen's introduction of the speaker, he referred to the coincidence that it was 12 years ago on October 20, 1897, that Mr. Chanute first presented the subject for this evening's address when he read his paper on "Gliding Experiments." Mr. Chanute's address this evening was on "Recent Progress in Aviation" and was illustrated by a large number of lantern slide views, of different flying machines. After Mr. Chanute had completed his address there was an exhibition by means of moving pictures, of the flying machines at Rheims, France.

The meeting adjourned at 10.20 P. M.

JOINT MEETING, October 22, 1909.

An extra meeting of the Society (No. 672) being a Joint-Meeting of the Electrical Section, w.s.e. (No. 44) and of the Chicago Branch, American Institute of Electrical Engineers, was held Friday evening, October 22, 1909.

The meeting was called to order about 8.30 P. M. with Mr. J. G. Wray in the chair; there was about 120 members and guests present. The minutes of the last proceeding Joint-Meeting, held May 25, 1909, were read and approved.

The Chairman introduced Mr. W. L. Abbott, m.w.s.e., who presented his paper on "Central Station Economies." Discussion followed from Messrs. J. G. Wray, R. F. Schuchardt, A. Bement, E. N. Lake, R. H. Kuss, O. E. Olson, W. E. Keily, — Pearson, George Jones, B. E. Strohm, D. W. Roper, E. F. Smith, and F. W. Bernhardt, with a closure from Mr. Abbott.

The meeting adjourned about 10.30 P. M.

J. H. WARDER,
Secretary.

BOOK REVIEWS

LAW AND BUSINESS OF ENGINEERING AND CONTRACTING. By Charles Evan Fowler, M. Am. Soc. C. E. New York, McGraw Publishing Co. Cloth, 6 by 9 in.; pp. 162, including index. \$2.50.

In this age of technical specialization it is a pleasant and profitable occupation to take up a book dealing with the human side of engineering and to find, as in this case, the matter discussed from a high and at the same time a practical standpoint.

In this book the author deals in a fair and broad way with the relations existing between the various parties to engineering and contract work, and in handling this subject he has brought, not only a broad and clear vision and a vein of true optimism, but enough of practical experience on both sides of the line to know thoroughly what he is talking about.

Of course, it is easy to criticise some of the minor details of the book. Engineers will disagree as to the merits of the author's specifications for steel roofs and buildings, found on page 39, but they certainly contain enough valuable matter to warrant their publication. The writer would personally criticise Clause No. 10, which provides for increasing the figured loads in buildings subject to the action of gases, and would prefer to substitute a clause increasing the minimum thickness of material and rigidly prohibiting vacant spaces that cannot readily be cleaned and painted. There is also an obvious error in the wording of this clause which seems to apply to *all* mill buildings instead of those especially subject to corrosion, as is evidently intended. The writer would also specify open-hearth steel, as he considers Bessemer steel

decidedly inferior and out of date for structural purposes. Clause No. 59, in regard to length of compression members, seems meaningless as written. The classification is sometimes very bad, as when Clause No. 56, relating wholly to *workmanship*, occurs under the head of *details of construction*. The writer realizes that it is no easy matter to produce a specification that is free from ambiguities, contradictions, and verbosity. In the present edition, the author has done as well as most writers of specifications, but it is to be hoped that he will undertake a thorough revision before the next edition is issued, either separately or in this book.

Taking up the subject matter in detail, the first chapter deals with the relation between the engineer and the contractor. It is short, but leaves little to be desired. He complains of the lack of business training on the part of so many engineers and advises business preparation for the profession. He speaks a strong word for sincerity, open dealing, honesty and fairness on both sides, and warns the engineer or owner against the acceptance of "abnormally low bids" unless they are made by responsible parties, upon thorough understanding and for special reasons. Anyone connected with engineering work would find this chapter profitable and inspiring.

Chapter 2 deals with "ordinary forms of contracts," giving the essential features of a contract very clearly, together with explanations showing the reasons for each step. Several excellent contract forms are included in this chapter.

Chapter 3 deals with "ordinary specifications" and contains the author's specifications for steel roofs and buildings, and the Navy Department's specifications for structural steel and wrought iron mill products. The author prefaces the specifications with some excellent general remarks. The writer, however (in common, he believes, with most structural engineers) would be inclined to favor the "American Railway Engineering & Maintenance of Way specifications" as a model of a bridge specification at the present time rather than "Theodore Cooper's Specifications."

Chapter 4 contains a good many special forms of specifications, with comments and criticism. Such forms are useful as examples of engineering English and of clear statements of conditions and nature of work.

Chapter 5. "Special forms of contracts." This brief chapter is excellent, although it contains no sample contracts under this heading. The incorporation laws of several states are summarized to a limited extent and a form of articles of incorporation is also given. The author states that "the drawing of a special engineering contract should never be turned over entirely to an Attorney. Lawyers very seldom know more than the general principles of engineering, and cannot always draw up such a contract correctly * * * it should first be written out in full and then submitted to an Attorney for his consideration of the legal points involved." This clause will stand repeating with emphasis.

Chapter 6 is also very good. The author quotes from a recent article, "An engineer should never write a specification under which he would be unwilling to work as a contractor." This is a good statement of the "golden rule" and will also bear repeating. The hints for inspectors and the principles of inspection are also good and bear witness to the author's experience and ability.

Chapter 7 deals with estimating costs and contains much good material. The data given are more or less approximate, but one would hardly go to such a book as this for absolute cost data. The important thing is that the book gives valuable information as to methods and systems which will prove useful, especially to the young engineer.

Chapter 8, on "Bidding," covers briefly a very important subject. This chapter is interesting reading. Many of us can bear witness to the fact that "the matter of putting in bids and winning out is largely one of experience and 'knack,' and a man has to have a natural idea about these things to make sure of getting a reasonable amount of work to do, in this age of competition." This is another statement of the human side of engineering which does no harm to state: We all know able estimators and bidders who seem to be

always losing out, and are always complaining of their luck or of the many cases in which they have been "thrown down." It should be the aim of every engineering contractor to cultivate this "knack" or intuitive grasp of condition, which often measures the entire distance between success and failure.

Chapter 9, on "organization," explains the ordinary business structure and is useful for the student. There are also some good general observations. For instance, "In this, as in most other things which are made a success, genius simply consists of hard work and there is no 'royal road' to making the wheels turn round continuously and smoothly." This is a good maxim. The author also shows that he understands the value of real efficiency, when he states that the "best foreman is the cheapest" and "a poor foreman will easily drop the estimated profit on a job."

The last chapter on "Contract Law" consists largely of extracts from "Clark on Contracts" and contains a great many legal statements and maxims that the engineer ought to know.

The book is well printed and bound, has an excellent index, and is suitable for class work or reference. The writer considers it especially valuable for the former purpose. It is essential that our engineering university graduates should go out in the world with some conception of business law and business ethics. They spend so much time in filling their brains with fact and method that they have little time for work that helps to make them into *men*. This book is in the right direction and our thanks are due to the author. A. A.

WHEN RAILROADS WERE NEW. Charles Frederick Carter. 324 pages. 6 by 8½ inches, a number of full-page illustrations and a copious index of 10 pages, in full cloth. Price \$2.00. Henry Holt & Co., New York.

This is a delightful book, "as fascinating as a novel," a history of the struggles, the failures, and the triumphs of the pioneer railroad builders. With our present railroad construction and maintenance, and with the tens of thousands of men over the country who have had practical experience in such work, to learn of the entire absence of all knowledge of railroad building "when railroads were new" now so commonplace, is interesting and amazing. And all within the space of the last three generations, or 100 years. It was as recent as 1812 that Col. John Stevens, of Hoboken, published a pamphlet to show the advantages of railways and steam carriages over canal navigation. The celebration of the opening of the Boston and Worcester Railroad was held in Worcester, July 6, 1835, on which occasion the proud claim was made that they had traveled all the way from Boston, 42 miles, in less than three hours.

It was about 1827-8 that the first railroad in the United States was completed, built by Gridley Bryant, from the granite quarries near Quincy, Mass., three miles long and down-grade to tidewater on the Neponset River, and solely for the carriage of granite from the quarry to the shipping point. It cost \$11,250 a mile, but reduced the cost of transport of the granite blocks to one-sixth of that previously. Two horses, the only motive power used, could haul 40 tons at a speed of 4½ miles per hour. The construction of this short road was substantial, and its operation was an object of great interest, many people traveling a considerable distance to see it.

A very illuminating view of the advance in railroading, particularly in the motive power, is an illustration of two locomotives drawn to the same scale. One is the enormous "2600" Mallet Articulated Compound, weighing 410,000 pounds, and the other is the small locomotive built at the West Point Foundry, New York, in 1830 for the Charleston and Hamburg R. R. in South Carolina. It was on the advice of that eminent engineer, Horatio Allen, that the directors of that railroad voted to construct and equip their road for steam locomotion. Though in the beginning, American engineers, as Horatio Allen and others, made careful studies of European practice, to apply to this country, yet Yankee invention and initiative were so prominent a factor in the development of these public works that in 1840 "M. Thiers, the great Historian and Statesman, then Prime Minister of France, recognized American supremacy in rail-

road building in that year by sending Michel Chevalier, a distinguished engineer, to study our methods for the benefit of French roads."

So much in a very condensed form for "The Dawn of the Railroad Era." This chapter is naturally followed by accounts of America's Pioneer Railroad, the "Baltimore and Ohio," which had its first conception the evening of Feb. 12, 1827, in the house of a Quaker banker of Baltimore, when some 25 of the most influential men of that city gathered to discuss the feasibility of a railroad from Baltimore to the West. "At that time there was no such thing in existence as a railroad for transporting passengers and merchandise between distant points." Much of this chapter is of great historical interest, and it is hard to comprehend that at that time how densely ignorant were the men of business and public affairs, of everything pertaining to railroads. It was simply so early in the history of such work, that there was no knowledge of such things.

It was about this time that a beginning was made toward the "Erie." The charter of the "New York and Erie Railroad" was granted April 24, 1832, but there was a long hard fight before the road was completed. To build 500 miles of railroad with much local opposition and the politicians being opposed, as it was a menace to their interests in the Erie Canal, made the task one of great difficulty. So much had to be learned, *de novo*; there was no telegraph, and trains were run by a set of rules and time cards, not from a dispatcher's office. Even the simple expedient of the conductor signalling the engineer when to start or stop, by a bell on the locomotive operated by a cord from the train, came into existence on this road about 1842. The road was completed and a train ran through to Dunkirk in May, 1851. The account of this first through-trip, with the celebrating, the feasting, the speeches, etc., etc., is full of interest. It was this year that witnessed dispatching of trains by telegraph on the Erie road.

The next chapter of this book relates to the Pennsylvania Railroad, where the local opposition, with their vested interests in turnpikes, stage-lines, and Conestoga wagons, was perhaps more severe and prolonged than elsewhere. The first railroad in the Keystone state was from Philadelphia to Germantown and Norristown, opened for traffic in June, 1832, and it was on this road that "Old Ironsides," the first locomotive built by Matthew Baldwin, of Philadelphia, was first operated.

The Vanderbilt System, made up of a great number of short and independent sections of railroads in New York, is the subject of Chapter V. An illustration shows the first train operated in New York between Albany and Schenectady in 1831. By 1850 it was possible to get a through ticket from Albany to Buffalo, and though the running time was nominally 14 hours, usually a good deal more time was occupied in transit.

Other chapters of this fascinating story relate to railroads in the Middle West—"Incubator Railroads" the author calls them—as projected in Ohio, Indiana, Illinois, etc. This was about the second quarter of the nineteenth century.

Of very great interest in the narration, in the closing chapters, of the construction and early operation of the transcontinental roads. The Union and Central Pacific roads, the Kansas Pacific, in which our own General Dodge had a hand about 1867-8, and the Santa Fe, and its fight with the Denver and Rio Grande. The final chapter of the book describes much of interest in the construction of the Canadian Pacific Railway. It is hard for business men in our cities, surrounded by the comforts and conveniences of a modern urban community, to comprehend what the engineers engaged in the survey and construction of this road in the Canadian Northwest, had to undergo. But they "made good" and the road was built, with the result of a marvelous growth and development of that country. As remarked at the beginning of this notice, the book possesses great historical and biographical value and reads as good as a novel.

W.

BRICKLAYING SYSTEM. By Frank Gilbreth. The Myron C. Clark Publishing Co., Chicago and New York. Cloth, 6 by 9 inches, pp. 330; 167 illustrations and 73 hand charts. Price \$3.00 net, postpaid.

Mr. Gilbreth has made a study of methods with a view to minimizing time and effort in securing results. His work as an organizer and systematizer is well known to all contractors and engineers.

In this book he takes up one of the oldest crafts in the world and shows that modern methods are far superior to old time "word of mouth" instruction. From generation to generation journeymen bricklayers have handed to apprentices the kinks and habits of preceding generations of journeymen. The few books in existence on the subject were in no sense texts.

The author of this work understands bricklaying because he worked with bricklayers for years. He learned all that could be learned orally and read all that was printed. He has for many years been a successful contractor, and in this book he tells all about the methods that have made him famous.

His method of training apprentices is given and an exhaustive chapter on "Motion Study" is a study in the analysis of a very ordinary trade, showing every motion a man goes through in laying brick. Charts are given, so apprentices may conduct motion studies for themselves, and learn how to eliminate unnecessary motions. Such a study could be well applied to other lines of work.

The chapters are as follows: Training Apprentices; Methods of Management; Methods of Construction; Routing of Material; Scaffolds; The Gilbreth Scaffold; The Packet System; Method of Building Tall Chimneys; Mortar; Bricks; Bricklayers' Tools; Lines, Plumbs, and Poles; Motion Study; Methods of Laying Brick Under Special Conditions; Finishing, Jointing and Pointing; Arches and Chimney Breasts; Tearing Down, Cutting Out, and Patching Brickwork; Bond.

The chapter on bond contains a great number of diagrams which will be very useful to architects and designers for the same attention to detail is shown here as in the chapter on Motion Study. The paragraphs are all numbered and are called rules. In fact, the book is a book of rules Mr. Gilbreth gives to superintendents and foremen on his work, the strict following of which has brought him success. Therefore, it is a valuable manual for superintendents of construction.

E. McC.

MODERN METHODS OF STREET CLEANING. George A. Soper, M. Am. Soc. C. E. Engineering News Publishing Co., New York. 201 pages, 6 by 9 in.; 90 illustrations. Cloth. Price \$3.00.

This is a valuable book, particularly to those concerned with Municipal matters. Much is now being written in the daily press, Chicago and elsewhere, in the matter of "cleaning up." The cleaning of the streets is perhaps the most important element of this movement toward civic betterment. If the public streets of a municipality are kept clean, it is powerful agent toward other desirable improvements.

A study of this book by the city authorities will give them much valuable information as to *what* should be done and *how* it is done, with deductions drawn from the practice in many important European cities. Chapter I recounts the "Use and Abuse of City Streets," and offers some explanation why street cleaning is so frequently extravagant in cost and inefficient in results. The "Fundamental Principles Applicable to Street Cleaning" is the subject of Chapter II, while Chapter III discusses the "Cleaning of Pavements." This is followed by "Disposal of Refuse" in Chapter IV, and a "Summary of European Methods of Street Cleaning" in Chapter V.

The street cleaning of London, Manchester, Paris, Hamburg, Berlin, Cologne, Amsterdam, and New York is the material for subsequent chapters. The illustrations of vehicles for sprinkling, sweeping, and transporting the waste material are of value and interest.

A suggestion that might be applicable here, is the storage in piles in suit-

able locations, of the street sweepings which in a year or two, under the action of frost, rain, and the atmosphere, particularly if worked over a few times, would furnish a large amount of top dressing for the lawns of the city parks. The item of cost for such work in different localities is a valuable part of this book. But the author did not find it practical to deduce principles of general application, as the nature of the work and the character of the information available does not permit of precise deduction. The many varieties of character and conditions of pavement, of traffic, of weather, and of sanitary standards, prevent the treatment of this subject in an analytical method. W.

A TREATISE ON MASONRY CONSTRUCTION. By Ira Osborn Baker, B. S., C. E., D. Eng'g. Professor of Civil Engineering, University of Illinois. Tenth edition, entirely rewritten and enlarged. 8vo. (6 by 9 in.) 762 pages, over 100 tables, and 244 illustrations. John Wiley & Sons, New York. Cloth \$5.00.

It is a great pleasure to announce to the readers of the JOURNAL the advent of Prof. Baker's revised work. In bringing the work up to date the author seems to have spared no pains to make it as complete and reliable, within the scope covered, as possible from available data.

As in former editions, the work is divided into parts, chapters, articles, and numbered and typed sections. It is also well paragraphed and indexed. Part I (chapters I-V) treats of Materials; stone, brick, limes, cements, gravel, and broken stone. Part II (chapters VI-XII) treats of mortars, plain concrete, reinforced concrete, artificial stone, stone cutting, stone masonry, and brick masonry. Part III (chapters XIII-XVI) treats of Foundations; ordinary, pile, and under water. Part IV (chapters XVII-XXIII) covers masonry dams, retaining walls, abutments, piers, culverts, voussoir arches, and elastic arches. Specifications are given in three appendices.

The chapter on "Plain Concrete" is almost entirely new, while the three on "Reinforced Concrete," "Concrete Building Blocks," and "Elastic Arches," are added chapters.

Various diagrams form a part of the new illustrations. A greater proportion of the illustrations have descriptions in connection with the plate number than in the old editions, which is a decided advantage over those which are described only in the text. Considerable cost data are given throughout. The illustrations for retaining walls are up to date and well chosen. While the author has gone over the field thoroughly for available data on "Earth Pressure," we seem to be as far as ever from reliable and exact knowledge on this important subject.

The examples of "Wing Abutments," with one exception, are a very decided improvement over that given in the old editions. The new examples of "U" and "T" abutments are also much better than the earlier forms.

Culvert design is quite fully discussed, and illustrated by showing the latest practice in design. The subject of "Arches" is well treated and illustrated.

With the addition of 153 pages to the new addition, the width of margins have been reduced and the thickness of the volume is about $\frac{1}{4}$ in. less than the old. It may be remarked that coarse, heavy paper, wide margins, and coarse type with heavy leading, should have small place in the make-up of an engineering library. The quality of the paper and the binding of this book are excellent.

The new edition well merits a still greater popularity than that already enjoyed by the previous ones. C. K. M.

IRRIGATION ENGINEERING. By H. M. Wilson, Mem. Am. Soc. C. E. Sixth Edition, revised and enlarged, 6 by 9 $\frac{1}{4}$ in. XXIX + 625 pages, 38 page-plates, and 195 other illustrations. Cloth. \$4.00. John Wiley & Sons, New York, 1909.

An earlier edition of this work (the fourth) was reviewed in the pages of the JOURNAL in 1904, Vol. IX, page 447. This latest edition (the sixth)

has been considerably enlarged both in text and illustrations. The advance in the knowledge of irrigation, the development of the science of the conservation and utilization of water for irrigation, and the experience of engineers engaged in irrigation, has been so marked in the last half dozen years as to demand this revision of the earlier work.

The author is the Chief Engineer and has been Geographer and Irrigation Engineer in the U. S. Geological Survey; he has given considerable time and labor to bring his book up to date. Among other things, this includes the use of reinforced concrete in the construction of dams and controlling works of the reclamation projects. The magnitude of this portion of the Federal work is hard of comprehension by the ordinary reader.

In the spring of this year, more than 675,000 acres of land were under irrigation from reclamation projects, and nearly \$43,000,000 had been expended upon the construction of works, completed or in progress. But this is not all outlay by the Federal authorities and at the expense of the Union at large, for revenues from work constructed up to the beginning of this year amount to over \$1,070,000, which is available for use in future work.

In the plan of the book, the work is divided into three parts:

I—Hydrography, which includes Precipitation, Run-off and Stream Flow; Evaporation, Absorption, and Seepage; Alkali, Drainage, and Sedimentation; Quantity of Water Required; Flow and Measurement of Water in Open Channels; and Sub-Surface Water, Sources, and Sewage for Irrigation.

II—Canals and Canal Work, which considers Classes of Irrigation Work; Alignment, Slope and Cross-Section; Head Works and Diversion Wiers; Sluiceways, Regulators and Escapes; Falls and Drainage Works; Distributaries; and Application of Water and Pipe Irrigation.

III—Storage Reservoirs, under the headings of Location and Capacity of Reservoirs; Earth and Loose Rock Dams; Masonry Dams; Wasteways and Outlet Sluices; Pumping, Tools, and Maintenance; and Reclamation Service of United States.

The book contains a number of valuable tables applicable in a study of irrigation work, and the illustrations are satisfactory.

It is to be noted that the author of the book refers to and has illustrations of hydraulic works elsewhere in the United States than in the irrigated regions, and he has also drawn upon foreign practice for examples and descriptions of notable works, as in India, Australia, Egypt, and in Europe.

Altogether the book is a valuable one and of general as well as special interest. The bibliographical notes and references distributed through the book following the text, is a valuable feature. W.

MANUAL FOR ENGINEERS. Tables and other Data for Engineers and Business Men. Compiled by Chas. E. Ferris, Prof. of Mech. Engineering, University of Tennessee. The University Press, Knoxville, Tenn., 170 pages, 3 by 5½ in. leather bound. Price, 50 cts.

This is a convenient little pocketbook, (vest-pocket size) prepared by and in the interest of the University of Tennessee. It opens with a few pages of information about the University, Faculty, Courses of Instruction, Costs of Tuition and Living, etc. The great bulk of the book is made up of a variety of tables to which there is frequent reference in everyday life, as, Area and Circumference of Circles, Squares and Cubes, Square Roots and Cube Roots of numbers from 1 to 1019. Decimals of an inch for fractions of 1/64 to unity, and decimals of a foot for each 1/64 of an inch to 1 foot. Also weight and sectional area of square and round bars, per foot in length, weight of sheet metal, tables of trigonometrical functions, sines, tangents, and secants; a small condensed table of logarithms of numbers; also standard dimensions of boiler tubes and welded W. I. steam and gas pipe, and other tables of interest in mechanical engineering. There are also several pages of earth-work tables, of loss of head by friction in pipes, etc., etc. Also tables of

diagrams and formula for bending moments and shears of beams with different loadings, and a table of weight and specific gravity of many different substances. Also, of value to electrical workers, are tables of copper wire and wiring tables for 100, 220, 500, 1000, and 2000 volts. Finally an "Interest Table" at the rate of 6%, 7%, 8% and 10% on sums from \$200 to \$1000 and for the time of 1 day to 6 years. This would appeal to many business men as related to their commercial transactions.

There should be a good demand for this handy volume, which is the 13th edition. W.

PROBLEMS OF CITY GOVERNMENT, by L. S. Rowe, Ph. D., LL. D., University of Pennsylvania. D. Appleton & Co., New York, 1908. 5¼ by 8 in. 358 pages, including index. Price \$1.50.

"The historian of American institutions," says Prof. Rowe in the introduction to his "Problems of City Government," "will probably designate the last quarter of the nineteenth century as the period of municipal experimentation. The history of municipal institutions during this period negatives many of the accepted views of Anglo-Saxon conservatism;" and he goes on to say that an analysis of the conditions of city life in the United States will disclose deep rooted causes fully explaining the unsettled condition of our municipal policies and principles. It is the purpose of the volume above noted, to present the results of such an analysis, and to suggest from the data obtained, the proper line of progressive evolution to be followed in attempting to better present conditions.

In carrying out this program, the author has produced a work that is both instructive and inspiring; *instructive* because, while no pretense is made to original research, the data presented being very largely from published sources, the facts that are derived from the investigations of others, are so collated and arranged as to give the reader a very clear apprehension of the larger aspects of the municipal problem from the point of view of the author; and *inspiring*, because this point of view is that of optimism, although a tempered and conservative optimism. While fully recognizing the difficulty of the municipal problem in this country, Prof. Rowe is, nevertheless, imbued with a democratic faith in the capacity of our urban population to govern themselves, if rightly instructed and directed. The general spirit of this book is therefore in cheerful contrast to the cynical and pessimistic tone of so much of the more popular "muck raking" literature on municipal conditions with which we have latterly become so familiar.

This faith, however, is not a faith in the efficiency of any particular form of city government. The author has no legislative panacea which is to be the cure for all the ills to which American city populations have fallen heir, in their preference for money-making rather than good government. On the contrary, the present work in its analysis of municipal conditions, is very largely concerned in demonstrating the utter fallacy, as applied to the government of cities, of the characteristically American political conviction that wherever there is a wrong there must be a legislative remedy, and that all the citizens of a politician afflicted community have to do to right the many wrongs received at the hands of their rulers, is to devise a more perfect form of government, constrain the legislature to make the same a law, and then turn the new machine over to the politicians again.

It is this blind faith in the efficacy of legislative remedies together with the application to the government of cities, as a result of such political principles of the system of checks and balances so typical of our State and Federal governments, that, according to Prof. Rowe, constitute the chief reason why our city governments have fallen so far short of the results accomplished in Europe. This is very convincingly developed in the chapter on "The Modern Municipality," where it is shown that within something less than a century, American municipal institutions have undergone a series of changes nothing short of revolutionary. This is first in the direction of a sub-division of administrative powers between the mayor and the branches of a bicameral

council, following the "checks and balances" theory of government, and later along the line of concentration of power in the executive with a consequent decrease in the power of the legislative assembly, as in the Greater New York Charter; or even to the extent of abolishing the Mayor and Council, and entrusting the entire government to a commission, as in the Galveston plan. During all this period of legislative experimentation, not altogether happy in its results, the cities of Europe, with but little change in their constitutions, have been making steady advance along what Prof. Rowe considers the true line of progress; that is, in obtaining the betterment of conditions by arousing public spirit and keeping it vigilant, and applying the force of public opinion through the traditional and legally established channels to the accomplishment of the results desired. This, in fact, is the course, according to Prof. Rowe, that American communities should follow in the future, rather than to waste their effort in the vain attempt to discover some utopian form of government which will operate automatically and without watching.

Lack of space prevents anything like an adequate summary of the contents of this valuable book. Those interested in the questions arising out of the relationship between city and state and the powers conferred by city charters, will find the chapters on "The Position of the City in the American Political System," and "Legal Powers of Municipalities," full of well digested information.

The last part of the volume is devoted to a discussion of municipal ownership of public utilities, and it is hardly necessary to say that the author stands on the affirmative side of the question. Very little credit is given to the stock arguments of middle-class conservatism, which is to the effect that better and cheaper service can be expected from private corporations. European experience is cited as a refutation of this; and as to the increased danger of official corruption with municipal ownership in control, the author considers this danger less than when city officers are subject to the pressure of private corporate interests. Moreover the conviction of the author, which permeates and gives character to the whole book, is that the solution of governmental problems in cities is *not* to be obtained by reducing the powers of city officials, and consequently their responsibility, but on the contrary may be better furthered by increasing such powers and responsibilities so as to call forth the best that there may be in the holder of the trust and further serve to awaken, and keep awake, in the public at large a vigilant public spirit. To be sure, there are arguments against this generous view, but it certainly has force.

P. H. T.

CONCRETE IN RAILROAD CONSTRUCTION.—Pam. 6½ by 8¾ in., 228 pages, many fine illustrations, half-tones and zinc etchings. Price \$1.00.

CONCRETE IN HIGHWAY CONSTRUCTION.—Pam. 6½ by 8¾ in., 136 pages, illustrated with half-tone cuts and zinc etchings. Price \$1.00.

CONCRETE CONSTRUCTION ABOUT THE HOUSE AND ON THE FARM.—Pam. 6½ by 8¾ in., 160 pages, well illustrated. Free distribution.

Though these books published by the Atlas Portland Cement Co., 30 Broad St., New York, are listed as "Trade Catalogues," they are much more than that, containing many illustrations of a variety of concrete structures for use in railroad and highway construction. Many of the zinc etchings are reproduced from working drawings, showing the dimensions, the reinforcement, etc. Instructions are given for the mixing of the concrete, the construction of the forms, the reinforcement, etc. The uses of reinforced concrete are so varied as to be beyond the limits of this notice, but include bridges and viaducts, trestles, culverts, piers and abutments, retaining walls, station buildings and train sheds, coaling stations, cinder and turntable pits, round-houses, signal towers, and bumping posts. Also warehouses, storehouses, grain elevators, water-storage tanks, docks, and tunnels.

The second of the above trio of books, has the sub-title "Text-book for Highway Engineers and Supervisors," and the first illustration is that of

the beautiful arched highway bridge in Yellowstone Park over the turbulent rapids of the Yellowstone River, just above the Falls, which was built by the U. S. Engineers in charge of that National Park some years ago. The book is full of valuable hints, tables, instructions, etc., to aid in the more general as well as scientific use of concrete. Illustrations and descriptions refer to highways, street pavements, sidewalks, curbs and gutters, culverts of many sizes and forms, bridges, sewers, retaining walls, fence-posts, hitching-posts, and drinking fountains.

The third book, relating to structures on the farm, etc., shows examples of yet further adaptation of this material. These include walls for cellars and for houses, stables, barns, silos, dairies, ice-houses, stairways, curbs, (about springs and wells), culverts and drain-tile. Greenhouses, chicken-houses and piggeries, water-tanks, and ice-boxes, may be built of concrete. These books are full of interest, are very clearly written, and contain many excellent and instructive illustrations of structures built of this plastic material. But such work should not be attempted by inexperienced persons after simply perusing the text. To engineers and artisans who have some knowledge of the subject, they will frequently give a valuable hint or suggestion as to what has or can be done with concrete. W.

TRADE CATALOGUES.

ENGINEERING INSTRUMENTS. Bausch & Lomb Optical Co., Rochester, N. Y. Pam. 7¾ by 10½ in., 68 pages.

This is a description, with prices, of the extensive line of engineering instruments as made by this company. The descriptions are clear and interesting reading, which are further enhanced by the illustrations. The makers of the instruments shown in this list, have the reputation for most excellent workmanship. Messrs. Bausch & Lomb also have a high reputation for the quality of their optical work as shown in their lenses, prisms, etc.

Some ingenious devices have been brought out by this company, and incorporated in their manufactures. Besides the compendious list of transits, levels, theodolites, and compasses, there is listed plane tables, leveling rods, measuring tapes, chains and pins, magnifying glasses, etc.

Messrs. Bausch & Lomb announce that a catalogue of astronomical instruments has been prepared for distribution to those interested. The book-work in this catalogue is of high character. W.

YALE & TOWNE, CHAIN BLOCKS, ELECTRIC HOISTS, TROLLEYS AND CRANES. Pam. 6 by 9 in., 70 pages, fully illustrated,—with tables, descriptive text, prices, etc. The Yale & Towne Manufacturing Co., No. 9 Murray St., New York, and Stamford, Conn.

It is now more than fifty years since Thomas A. Weston invented the differential pulley-block, and which soon proved its great usefulness in a vast variety of places. Subsequently many improvements, adaptations, and modifications were made, as the triplex and duplex chain-blocks, spur-gear and screw-gear, and of varying efficiencies. These were hand-operated machines, but with the development in the use of electric energy, it was natural that it should be employed as in electric hoists, which are particularly applicable in many situations. Tables show the range in capacity from one-half ton to twenty tons, with dimensions, prices, etc. It was a comparatively simple step to apply these lifting mechanisms to trolleys and cranes with overhead tracks. The same pamphlet shows a variety of metal-constructed crabs and winches.

The book work is very good and the illustrations clear and instructive to the construction and operating engineer. There is hardly a shop or factory, containing machinery, where one or another of these lifting machines would not prove very useful. These pamphlets can be had on request, of the Yale & Towne Manufacturing Co. W.

LIBRARY NOTES.

The Library Committee wishes to express thanks for donations to the library. Back numbers of periodicals are desirable for exchange and in completing valuable volumes for our files.

Since the issue of the JOURNAL for August, 1909, we have the pleasure to report the following additions to the library and gifts from donors named:

MISCELLANEOUS GIFTS.

- John M. Sweeney, M.W.S.E., Chicago, Proceedings of International Engineering Congress, Division of Marine and Naval Engineering and Naval Architecture. 1893, 2 vols. Cloth.
- E. E. R. Tratman, M.W.S.E., Chicago. Proceedings, American Water Works Association, 1908. Cloth
- Report of Royal Commission of New South Wales. Pam. and maps.
- Journal, American Society of Engineering Contractors, June 1909. Pam.
- Public Service Commission of New York. "Fire Protection along the lines of the railroads in the Adirondack Forest Preserve." Pam.
- Administration Report of the Railways of India, 1908. Paper.
- The Railways of Indo-China. Pam.
- Journal, Railway Signal Association. Pam.
- Univ. of Ill. Bulletin, No. 29. Pam.
- Bulletin No. 105, Amer. Ry. Engr. & M. of W. Assn. Pam.
- Bulletin, American Institute of Mining Engineers, May, 1909. Pam.
- Bulletins, International Railway Congress, March, May, 1909. Pams.
- Bulletin No. 9, Illinois State Geological Survey, Cloth.
- Water Supply & Irrigation Papers Nos. 224, 230, 231.
- Report of General Manager of Railways, Cape of Good Hope, 1908. Pam.
- Virginia State Geologist. Bulletins 2 & 3 Virginia Geological Survey. Pams.
- A. Twyman, Chicago. Bulletin No. 1, Virginia Geological Survey. Pam.
- 20 sheets of Details, Standards in freight car construction in English practice.
- C. C. Andrews, Forestry Commissioner, St. Paul, Minn. 11th & 12th Annual Reports of Commissioner of Forestry of Minn. Cloth.
- New Hampshire Agricultural Experiment Station, Durham, N. H. 19th & 20th Reports of N. H. Agricultural Experiment Station, 1906-1907. Paper.
- Sewerage Commission, City of Baltimore, Md. Annual Report for 1908. Pam.
- M. C. Clark Publishing Co., Chicago, "Bricklaying System," Frank B. Gilbreth, Cloth.
- Commissioner of Health, Harrisburg, Pa., Report of Pennsylvania Commissioner of Health, 1907. Cloth.
- City Statistician, Chicago, Chicago City Manual, 1909. Cloth.
- Engineering News Publishing Co., New York, "Modern Methods of Street Cleaning," Soper. Cloth.
- "Waterproofing," Myron H. Lewis. Pam.
- Chamber of Commerce, Pittsburg, Pa., Annual Report of President Lee S. Smith, May, 1909. Pam.

- Rose Polytechnic Institute, Terre Haute, Ind., "Memorial Volume Rose Polytechnic Institute, 1874-1909." Cloth.
- John Wiley & Sons, New York, "Irrigation Engineering," Wilson. Cloth.
- "A Treatise on Masonry Construction," Baker. Cloth.
- Onward Bates, M.W.S.E., Chicago, Bulletin Rensselaer Polytechnic Institute, 1909. Pam.
- N. P. Lewis, Ch. Engr., Board of Estimate and Apportionment, New York. Report on the Triangulation of Greater New York. Paper.
- C. W. Birch-Nord, M.W.S.E., Chicago, "General Specifications for Elevated Steel Tanks on Towers and for Stand-pipes." Pam.
- Corporation Commission, State of Oklahoma, Guthrie, Okla., First Annual Report of Corporation Commission, 1908. Cloth.
- Board of Trustees, Commissioner of Water-Works, Cincinnati, Ohio., Annual Reports 1905-8. 1 cloth, 3 pams.
- Board of Trustees, Commissioners of Water Works, Cincinnati, Ohio., Chief Engineer's Report, 1897-1909. Cloth.
- P. Blakiston's Son & Co., Philadelphia, Pa., "A Manual of Volumetric Analysis," Coblenz & Vorisek. Cloth.
- J. B. Henderson, Brisbane, Australia, Report of Interstate Royal Commission on the River Murray. Bds.
- S. E. Thompson and F. W. Taylor, Newton Highlands, Mass., "Extracts on Reinforced Concrete Design from the Second Edition of "Concrete, Plain & Reinforced." Pam.
- The Scientific Publishing Co., Manchester, Eng., "The Common Metals (non-ferrous)" Sexton and Primrose. Cloth.
- The Macmillan Co., New York, "Coordinate Geometry," Fine & Thompson. Cloth.
- M. K. Trumbull, M.W.S.E., Chicago, "Track Elevation, City of Chicago, to December 31, 1908." Cloth.
- League of Civic Clubs, Rochester, N. Y., "Rochester Social Centers and Civic Clubs." Story of first two years. Pam.
- Atlas Portland Cement Co., New York, "Concrete Construction about the Home and on the Farm."
- "Concrete in Highway Construction."
- "Concrete in Railroad Construction." 3 pams.
- Advisory Board of Supervising Engineers, Albany, N. Y., Report to Governor of Advisory Board of Supervising Engineers of Barge Canal. Cloth.
- University of Illinois, Urbana, Ill., Bulletin No. 4 State Water Survey. Cloth.
- Henry Holt & Co., New York, "When Railroads Were New," C. F. Carter. Cloth.
- University of Tennessee, "Tables and other Data for Engineers and Business Men." Leather.
- Commercial Club, Chicago, Plan of Chicago. Cloth.
- Houghton Mifflin Co., Boston, Remaking the Mississippi, by John L. Mathews. Cloth.
- Col. C. McD. Townsend, M.W.S.E., Detroit, Mich., Detail Drawings of Poe Lock at St. Marys Falls Canal, Mich. Cloth.
- Illinois Board of Charities, Quarterly Bulletin, Jan., 1909. Pam.
- C. L. Gould, M.W.S.E., Chicago, 5 bound volumes. The Mechanics of Engineering and of the Construction of Machines, by Weisbach.
- The Mississippi and Ohio River, by Charles Ellet, Jr.
- Report on the Filtration of River Waters, by James P. Kirkwood.
- Report of Committee on Coinage, Weights, and Measures, 1879.
- The Metallurgy of Iron and Steel, by H. S. Osburn.
- J. H. Warder, Secy. W. S. E., Chicago, Problems of City Government. 1908. Cloth.

- Wm. Busse, Chicago, Charity Service Reports, Cook County, Ill. Pam.
 Scientific Publishing Co., Manchester, Eng., Practical Alternating Currents,
 by Chas. F. Smith, Cloth.
 Metropolitan Water & Sewerage Board, Boston, Eighth Annual Report,
 1908. Cloth.
 Board of Health, Manchester, N. H., Annual Report, 1908. Pam.
 John Wiley & Sons, New York, Azimuth, by George L. Hosmer. Leather.
 Igneous Rocks, by Jos. P. Iddings, Vol. 1, 1909. Cloth.
 Exercises in Surveying, by Tracy, 1909. Leather.
 Chicago Academy of Sciences, Chicago, Annual Report, 1908. Pam.
 The Macmillan Co., New York, Simplified Methods of Calculating Reinforced
 Concrete Beams, by W. Noble Twelvetrees. Cloth.
 Lowell Water Board, Lowell, Mass., Annual Report, 1908. Pam.
 F. W. Huels, M.W.S.E., Madison, Wis., 1st, 2nd, and 3rd, Annual Reports,
 Inspector of Gas and Electric Meters, Madison, Wis.,
 1906-7-8. 3 pams.
 Pennsylvania Steel Co., Steelton, Pa., Reports on Blackwells' Island Bridge.
 1909. Pam.
 Joshua E. Borton, State Director, Trenton, N. J., Railroad and Canal Re-
 ports, 1908. Cloth.

GOVERNMENT PUBLICATIONS.

- U. S. Geological Survey, Department of Interior. The Production of Quartz
 and Feldspar in 1908.
 The Production of Tin in 1908.
 The Production of Peat in 1908.
 The Production of Petroleum in 1908.
 The Production of Mineral Waters in 1908.
 The Production of Gas, Coke, Tar, etc. in 1908.
 The Production of Graphite in 1908.
 The Production of Related Bitumens in 1908.
 The Production of Precious Stones in 1908.
 The Manufacture of Coke in 1908.
 Coal Briquetting in 1908.
 Bulletins, Nos. 373, 383, 387, 14 pams.
 Bulletins, Nos. 376, 378, 373, 385, 370, 341, 374, 375, 379, 383.
 Production of Phosphate Rock in 1908.
 Production of Slate in 1908.
 Production of Mica in 1908.
 Production of Iron Ore in 1908.
 Production of Chromic Iron Ore in 1908.
 Production of Talc and Soapstone in 1908.
 Production of Manganese Ores in 1908.
 Production of Asbestos in 1908.
 Production of Fluorspar and Cryolite in 1908.
 Production of Strontium in 1908.
 Production of Sulphur and Pyrite in 1908.
 The Cement Industry in the U. S. in 1908.
 Geological Maps, folios 160-166 inclusive.
 Water Supply and Irrigation Papers Nos. 224, 228, 229,
 230, 231.
 U. S. Department of Commerce and Labor, The Figure of the Earth and
 Isostasv from Measurements in the U. S. Cloth.
 Wood Distillation in 1908. Pam.
 A Century of Population Growth in the U. S., 1790-1900. Folio.
 Telegraph Systems, 1907. Folio.
 Religious Bodies in 1906. Pam.
 Department of Commerce and Labor, Bureau of Census, pams. Bulletins,
 99, 100.
 Pulp Wood Consumption in 1908.

- U. S. War Department, Reports of Secretary of War, Chief of Staff, Adjutant General, Inspector General, Judge Advocate General, 1908. Cloth.
 Reports of Armament, Transportation Supply, 1908. Cloth.
 Reports of Division and Department Commanders, 1908. Cloth.
 Reports of Military Schools and Military Parks, 1908. Cloth.
 Reports of Chief of Engineers, 1908. Cloth.
 Reports of Chief of Ordnance, 1908. Cloth.
 Reports of Philippine Commission, 1908. Vols. 1 and 2 with appendix; 2 cloth, and 1 pam.
- U. S. Dept. of Agriculture, Forest Service, pams. Silvical Leaflet No. 49. Circulars Nos. 163, 166.
- Bureau of Education, Pams. Statistics of Public, Society, and School Libraries of over 5,000 vols. in 1908.
- Bureau of Science, Manila, P. I., pams. Seventh Annual Report of Director, 1908.
- Commissioner of Education, Reports for 1909, Vols. 1 and 2. Cloth.
- Pan-American Scientific Congress, Report of the Delegates of the U. S. to the Pan American Scientific Congress, 1908-9. Cloth.
 Library of Congress. Pam.
 Select List of References on the Valuation and Capitalization of Railroads.
- Joint Committee of Conservation. Pam. Report of the National Conservation Commission.
- U. S. Bureau of Education, Index to the Reports of the Commissioner of Education, 1867-1908. Pam.
- Smithsonian Institution, Report of Progress of U. S. National Museum, 1908. Cloth.
- Reclamation Service, North Platte Project. Specifications and Advertisement. Pam.

BY PURCHASE

- Betterment Briefs. Jacobs.
 Handbook of Rocks. Kemp.
 Transient Electric Phenomena and Oscillations. Steinmetz.
 The New International Encyclopaedia, 1909. (Dodd, Mead & Co.) 22 vols.
 Directory of Iron and Steel Works of United States, 1908.
 Modern Power Gas Producer. Allen.
 Sewage Disposal Works. Raikes.
 Portland Cement. Meade.
 Designing and Detailing of Simple Steel Structures. Morris.
 Hydraulics and Its Applications. Gibson.
 Electric Railways. Vol. 2. Ashe.
 From estate of the late C. H. Tutton, M.W.S.E. :
 Roads, Streets, and Pavements. Gillmore.
 Practical Electricity. Ayrton.
 Thermodynamics of Heat-Engines. Reeve.
 Mechanics of Engineering. Du Bois.
 Heat and Heat-Engines. Hutton.
 Graphical Analysis of Roof Trusses.
 Experiments upon the Contraction of Liquid Vein, etc. Bazin.
 Hydraulics with Working Tables. Bellasis.
 Reinforced Concrete Construction. Turneure and Maurer.
 Symmetrical Masonry Arches. Howe.
 Elements of Precise Surveying and Geodesy. Merriman.
 Roorkee Hydraulic Experiments, Tables, and Plates.
 Retaining-Walls for Earth. Howe.

From estate of Dr. A. W. French:

- Missouri Geological Survey,—
- Annual Report, 1894.
- Reports on Areal Geology, 1896.
- Surface Features of Missouri, 1896.
- Missouri Bureau of Geology and Mines,—
- Biennial Report, 1898.
- Structural and Economic Geology of Missouri, 1900.
- Geology & Topography of Lake Superior Land District. Foster and Whitney, 1850.
- Mineral Resources West of the Rocky Mountains, R. W. Raymond, 1871.

MEMBERSHIP

Additions to Membership:

	GRADE
Deakman, Roy H., Chicago.....	Junior
Dencer, F. W., Chicago.....	Active
Jackson, Lawrence N., Greenville, O.....	Active
Righter, Addison A., Chicago.....	Active
Rosenbach, Rudolph G., Chicago.....	Active
Sayers, Wm. W., Chicago.....	Active
Vandersluis, W. M., Chicago.....	Junior

Corrected Addresses:

- Canfield, A. T., 2615 Wabash Ave., Kansas City, Mo.
- Cochrane, Hayward, Medford, Mass.
- Darling, J. N., High Grove, Cal.
- Davis, Garrett, Eldon, Mo.
- Decker, H. H., Belle Fourche, S. D.
- Fry, George W., Charlottesville, Va.
- Gersbach, Otto, Depue, Ill.
- Hazard, W. A., Buffalo, N. Y.
- Henderson, C. E., Univ. of Ill., Urbana, Ill.
- Lattin, Judson, Hamilton, Ont.
- Ludlow, Chas. G., 435 W. Lake St., Chicago.
- Melendy, R. P., 225 Dearborn St., Chicago.
- Nichol, John, Western Springs, Ill.
- Redfield, J. A. S., Hawarden, Iowa.
- Richards, J. T., Edison Park, Ill.
- Roeber, F., Blunt, S. D.
- Scheible, Albert, South Milwaukee, Wis.
- Six, W. L., North Milwaukee, Wis.
- Slocumb, E. C., Artesia, N. M.
- Swanitz, H. W., 1283 3rd Ave., San Francisco, Cal.
- Webb, A. R., Nyssa, Ore.
- Weber, Carl, Los Angeles, Cal.
- Whitcomb, E. B., Rogers, Ark.
- Worrell, J. C., 2907 Columbus Ave., Minneapolis, Minn.

Journal of the Western Society of Engineers

VOL. XIV.

DECEMBER, 1909.

NO. 6.

THE ROLLING OF SPECIAL SECTIONS OF IRON AND STEEL

WILLIS MCKEE, ELYRIA, OHIO.

Presented September 1, 1909.

Up to within a few years, the question of rolling irregular shapes has been one of comparative simplicity, as most of the shapes that it had been desired to roll were on the whole of comparatively plain cross section, but as it has been found desirable to have large quantities of metal bars and plates of more or less complex cross section, the question of rolling such shapes has become a matter of importance.

For the past five years the writer has been largely occupied in developing the possibilities of rolling steel into more or less complicated forms, and it is hoped that this brief discussion of the possibilities and methods of rolling such shapes will be of interest to the members of the Western Society of Engineers.

It is not the intention to treat the subject in an exhaustive or technical manner, but to present in as clear a way as may be, the possibilities and the limitations of rolling special sections. The boundary between what is acknowledged as the possible and the impossible, between the practical and the impractical, is exceedingly flexible, for numerous reasons.

First. Rolling mill men themselves do not know the possibilities of their own mills.

Second. New demands for large tonnages of certain sections justify the mills preparing for such sections and experimenting with the same, when a few tons or even a few thousand tons would not in any way recompense the mill in rolling them.

Third. New mills of new designs are opening up new possibilities.

Fourth. Often a proposition of some special section is not put up to the mill which is properly equipped with machinery and brains to handle anything out of the ordinary standard sections, or at least to handle the particular sections in question.

Neither the old school of "do as your fathers did" mill man, nor the technical man without extensive mill experience, is qualified to

say what can and what cannot be done. In a few mills there are organizations which are composed of a number of technical men together with some mill men who have been raised in mills and know mill conditions from start to finish, from a practical standpoint, and at the same time are willing to try to do new things in new ways, this is about the only combination that is able to work out the new problems which come up. The writer has been told by rollers and roll designers, that certain things were impossible, because they had never seen them accomplished, and the only way we were able to get around such opposition was to get new rollers and roll designers, as we knew that as long as the mill men took that position they could block any scheme that came up. It is absolutely necessary in order to get best results, to work on the supposition that everything can be done until it has been shown that it cannot be done.

Fifth. Necessity makes many things possible which do not originally appear so; for instance, the old two-piece rail. Most modern mill men would say that this section could not be made, notwithstanding the fact that it was manufactured years ago when steel was being first introduced; the head of the rail was of steel, while the flange and web were of iron. (Fig. 1.) Although this was a failure as a rail, it is a very interesting example of early mill work.

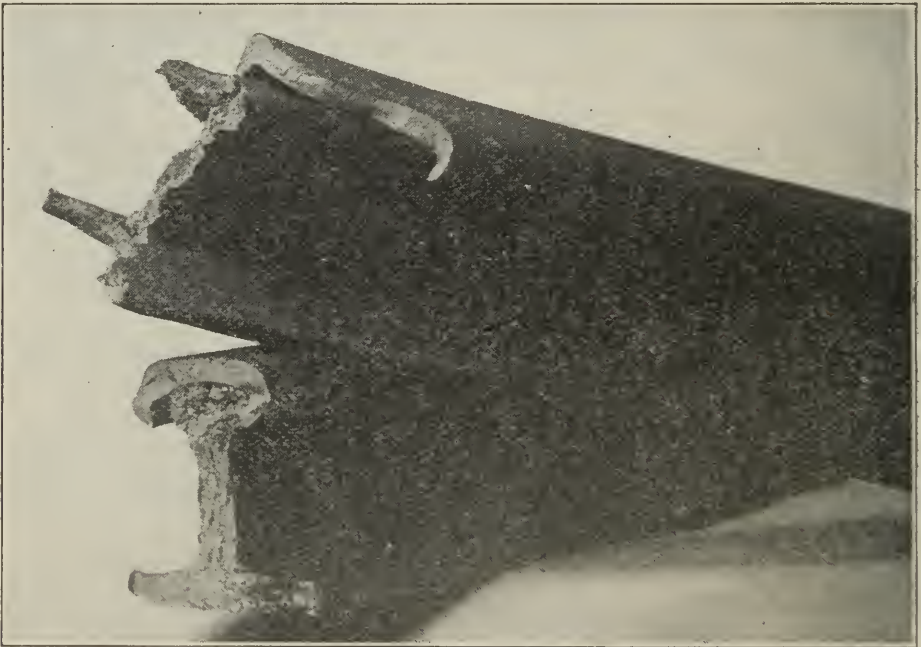


FIG. 1. IRON RAIL WITH STEEL HEAD.

Rolls are practically dies, which in revolving form the metal to their contour. It becomes necessary, therefore, to confine our rolled sections to such shapes that the rolls, in the last roll pass, will come in contact with the whole of the surface of the section to be rolled.

The illustration (Fig. 2), shows how it is customary to arrange the last pass in the rolls in rolling "I" beams, "Z" bars, splice bars, etc.

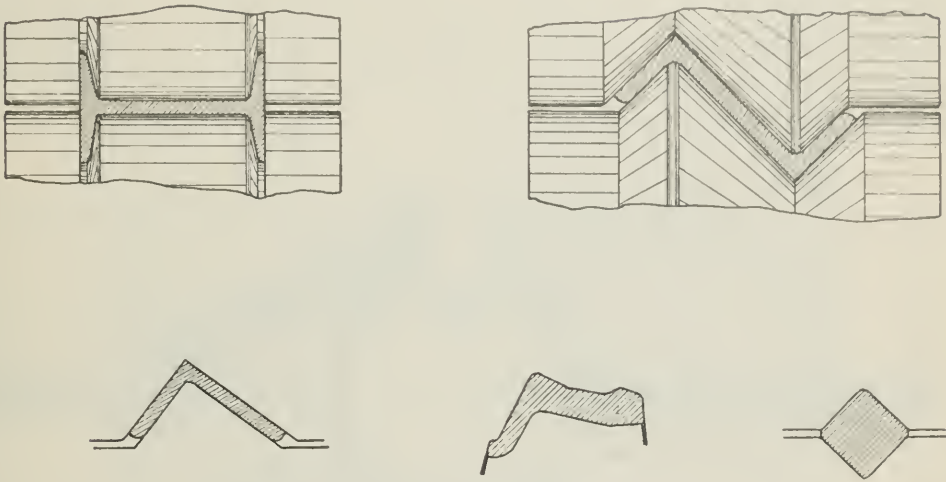


FIG. 2. STANDARD SECTIONS.

This rule is apparently deviated from in the case of rolling some sections, such as lock piling (Fig. 3), but this is not truly a deviation

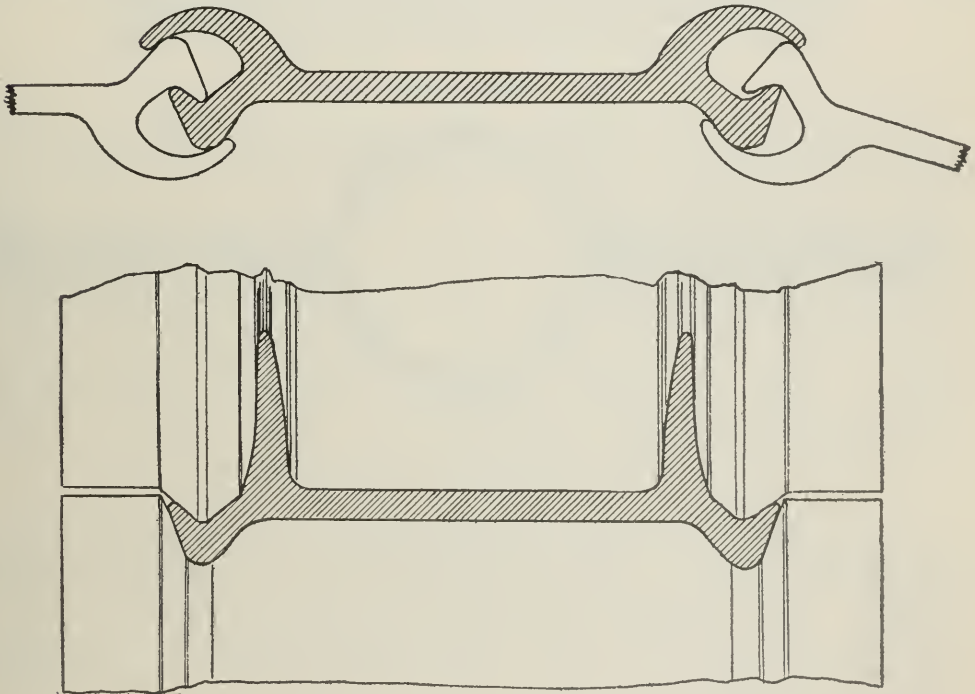


FIG. 3. STEEL SHEET PILING.

tion from the rule, as these sections are rolled so that the material can clear the roll, and then in the last pass no work is performed but in bending over the flange. In other words, it is rolled in such shape that the rolls can come in contact with all the section, and

then it is simply bent over in a bending pass, in which there is no rolling or reduction. In this section, if it were required to make an absolutely perfect bar, it would be necessary to use the mandrel to hold out the piece in this bending pass. If this were not done, there would of necessity be some irregularities in the section that the roller could not control, as the rolls cannot come in contact with both sides of the flanges in the last pass.

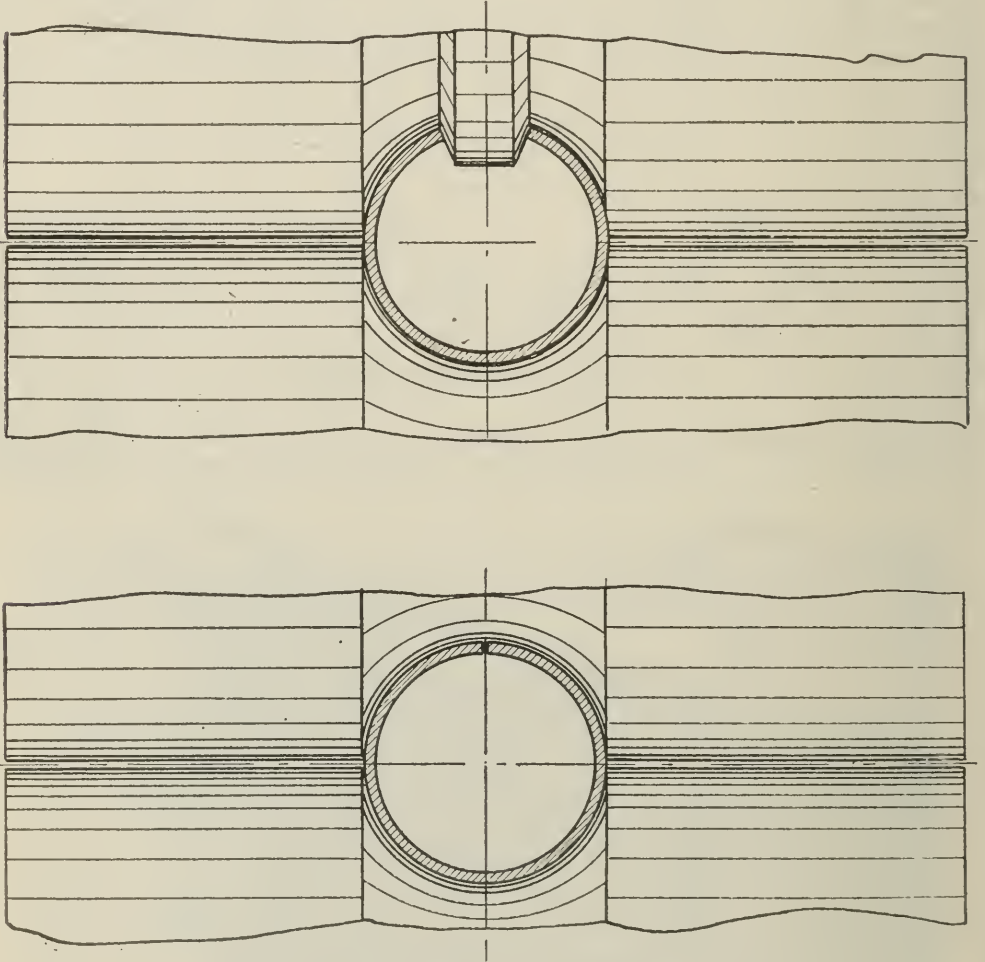


FIG. 4. DOOR HANGER AND STRUCTURAL TUBE.

Another example of somewhat similar rolling is the rolling of a door hanger (Fig. 4). In this instance we do not have just the same trouble. As the section is circular it can be conformed outward by the piece being tightly confined against the tongue of the top roll, but the pass that forms this section up is strictly a bending pass, and not a rolling one.

The writer has had considerable experience in the manufacture of structural and bedstead tubing (Fig. 4), which is formed up in a mill, but we would hardly consider that we rolled the tubing, although the piece leaves the mill in the shape of a tube. In reality we roll the skelp or flat strip of steel, and then form the same up

into the round by means of bending rolls and guides, but there is no reduction of the section after beginning to form it up, so it is in reality a hot continuous bending operation, and not a rolling one. We roll this tubing from high carbon steel stock, and when desired braze the seam. On account of the nature of this stock, it is found more desirable in many places than the ordinary welded tube.

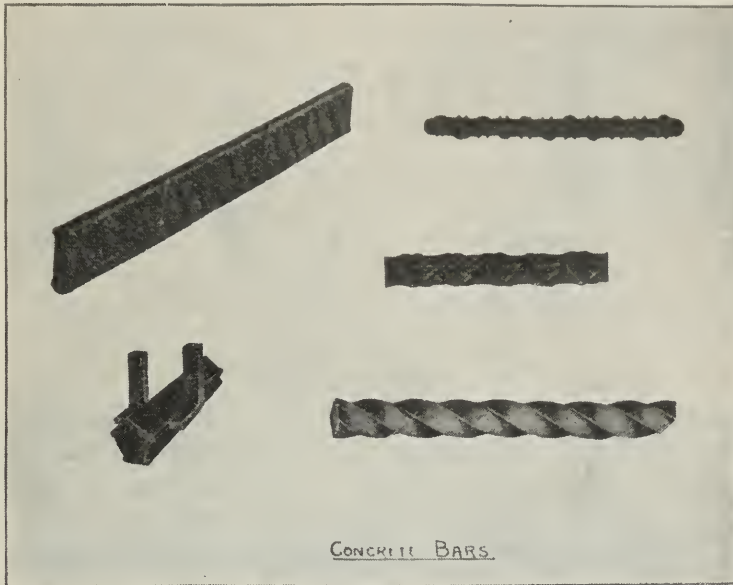


FIG. 5. CONCRETE BARS.

Concrete reinforcing bars (Fig. 5), have become a large tonnage proposition, and rolling mills have done all in their power to meet the demands of the engineer for bars that will at all points have practically the same area of cross section, and at the same time have such irregularities as to properly attach them to the concrete. With the exception of sections like the Kahn, which are slit after being rolled, and the twisted bars, practically all these sections are rolled on rolls that have had irregularities milled or chipped into them. Rolling mill men naturally do not desire rollings of this kind, for the reason that they have to be equipped to finish their rolls in a milling machine at an additional cost, and then on account of the nature of the rolls, it is impossible to roll a tonnage equal to that produced in plain rolls. It is also impossible, as a rule, to use a chilled finishing roll on such work, on account of the difficulty of finishing the same, and it is necessary to fall back on steel rolls, which will not last as long as chilled rolls, and which roughen up very soon. Of course, such little roughnesses on the concrete bar, are not usually regarded as serious. The twisted bar is rolled straight, and is afterwards twisted, in some mills on the hot beds before it cools, while at other plants, it is twisted cold.

Steel columns have for years been made in two ways. Small ones of a single "I" beam, and the large ones of built up sections, the point

where it became expedient to change from one to the other being usually determined by the radius of gyration of the "I" beam in the line of least resistance, the beam often being many times too strong in the other axis. It is impossible to overcome this in an ordinary beam, as the legs of the beam must have a decided taper,— $16\frac{2}{3}^\circ$ being the usual practice,—in order to clear the rolls, and it is impossible to make the flanges long. The left of Fig. 6 shows one

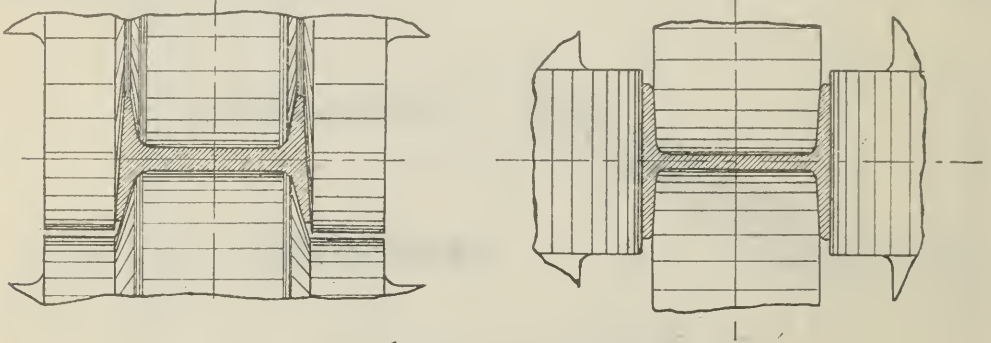


FIG. 6. ROLLING I BEAMS.

of the reducing passes. In this pass, the bottom flanges are being lengthened, while the top flanges are shortened, because the same roll is on both sides of these flanges. The demand for an "I" beam of practically square section led to the installation in Germany and afterwards at Bethlehem, Pa., of special mills to roll such sections. These mills are arranged with two sets of rolls in the same plane, but with axes at right angles, the one set conforming the inside, and the other the outside of the beam. In these mills it is possible to roll sections with long flanges, and with flanges whose sides are nearly parallel. It is claimed, with seeming justice, that the metal of the section rolled on such a mill is of a more homogeneous character than if rolled by the former method, because it is possible to make practically equal reductions in the several parts of the sections in the succeeding passes, so eliminating the tearing tendency which is natural in the old style rolling. Another advantage claimed is that the circumferential speed of the rolls at point of contact is always practically the same, while in other mills it is often nearly twice as great at some points as at others, causing slipping and distortion of the fibre of the steel.

In Fig. 7 is shown two methods of rolling channels, which are employed in order to get the required length to the legs. Now, if it were necessary to roll a similar section with a third projection near the center, one would be unable to make this third projection as long, as it would be impossible to use either of these two schemes in lengthening this third projection. If it were desired on the other hand to have only one projection, and it a central one, this projection could be given the required length by turning the bar on edge and dividing the rolls on the line of the projection, thus bringing one roll into contact with the top, and the other with the bottom side of the projection.

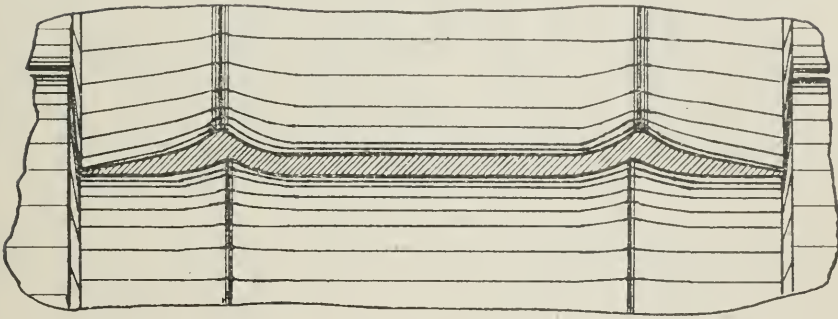
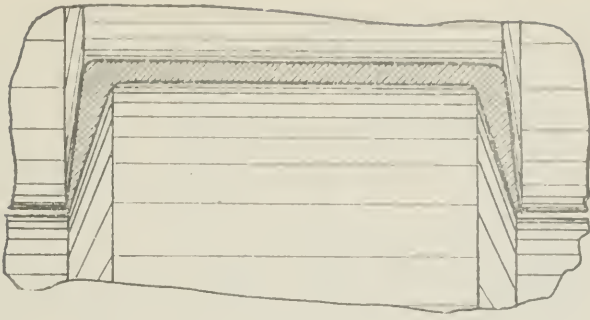


FIG. 7. ROLLING CHANNELS.

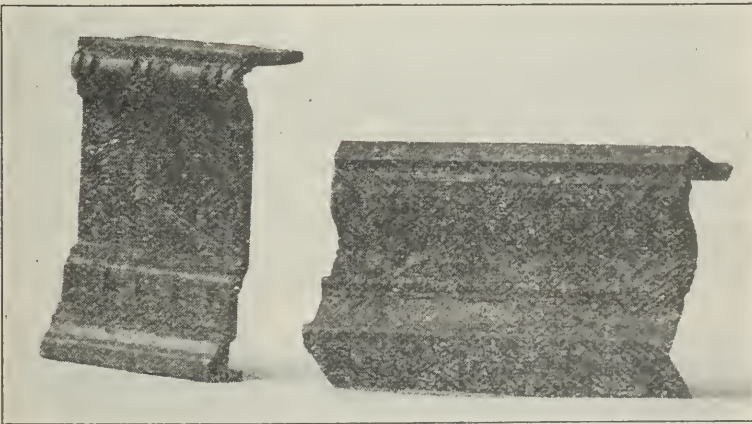


FIG. 8. FANCY MOLDINGS, ROLLED.

In Germany many sections of fancy molding (Fig. 8) are rolled and sold for prices ranging from \$100 to \$200 a ton. Such work has not appealed to the American rolling mills, because there are but limited tonnages of each section, and also because the carving

of the rolls for such work is laborious hand work, which Germany and some of the other continental countries with their cheap labor, are especially fitted to handle. American mills are specialized mills, and they are almost all striving for tonnage. It is difficult for some people not in the business to understand why a mill should want \$5 to \$10 extra per ton for some special section, besides making the customer pay for the cost of the rolls. The writer's own experience has been, that very little money can be made on a small order which demands a special rolling, even if the section is a standard one. The fixed charges, the delays due to setting the rolls and getting the order started, raise the cost in a surprising manner. On the other hand, give a rolling mill today a *bona fide* order for five to ten thousand tons of even a very difficult and unusual section, there are mills so equipped that they will be glad to take it at a very reasonable price, expecting to get their cost minimized on account of the size of the order.

When first interested in the manufacture of tie plates, the writer noticed that there were two main types of these made of rolled steel. One with the flanges on the bottom, and the other with a shoulder on top to take the thrust of the flange of the rail. Plates without either the flanges or the shoulder were seldom used and it was evident that a large number of the tie plate users desired both the flanges and the shoulder, but being unable to get both in a rolled section, took their choice; some the shoulder, others the flanges. This naturally led to a study of the proposition, and in the ignorance of the writer, he could not see why there was not a fair chance, at least, of being able to roll a plate with *both* the shoulder and the flanges. However, there were a number of reasons given as to why this could not be done. One was that it would be impossible to reduce the section enough in one pass to get such a shoulder as was required. Another was that the roll itself would "spall" at the shoulder. The third, that the reduction in the body of the plate would be much more than it would be possible to put on the flanges, thus causing the flanges to break. We experimented only a short while until we were convinced that we would be able to meet the demands of the engineers, but in order to do this, it was necessary to do what all our friends in the rolling mill business had told us was impossible. We rolled tie plates, $\frac{3}{8}$ in. thick with a $\frac{3}{8}$ in. per-



FIG. 9. TIE PLATE BAR, SHOWING SLIP IN ROLLING. SPACES BETWEEN SHOULDERS SHOULD BE EQUAL.

pendicular shoulder, and in order to do this, it is evident, even to the casual observer, that it is necessary to reduce the section by over 50% in the finishing pass. In practice, this reduction is as much as 60 to 70%. To a mill man used to only 10 to 20% reduction in the finishing pass, this looked impossible. There was found in practice two difficulties which bothered us. One was the irregularities between the shoulders, Fig. 9. That is, when rolling a bar of plates that was supposed to be 8 in. between the shoulders, if the top and the bottom rolls were not properly pitched, and all other conditions were not perfect, there would be a slip in the rolling, so that one roll and then the other seemed to govern the speed of the piece. Again, the reductions are so excessive that at times when a new smooth roll is put in the mill, the speed of the piece will no longer be governed by the peripheral speed of the rolls, with the result that some plates are practically half of the length they should be. As knowledge of these conditions has been gained, it has been possible to keep these variations within reasonable limits. Another trouble was from the piece buckling as it left the rolls. This seems to be caused by the difference in the reduction on the bar at the shoulder and at other points along the bar. As it is absolutely necessary that the base of the rail should have a good bearing in front of the shoulder, at first we straightened every plate. It then occurred to us, that as the place a tie plate usually failed was at the shoulder, it would be well to cut away the top

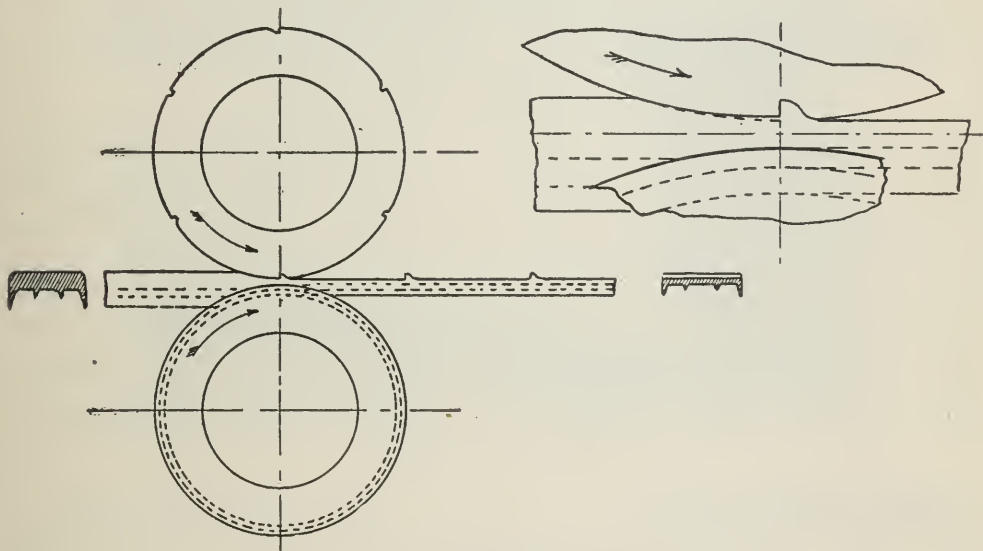


FIG. 10. ROLLING M'KEE TIE PLATES.

roll, as shown by dotted line in Fig. 10. This left the plate flat on the top surface and with a swell or reinforcement on the bottom side. In this way and at the same time, we were enabled to get around our difficulty and give the railway engineers the plates reinforced at their weakest point. In rolling sections of this kind it is of course necessary to make the controlling circumference of

the rolls a multiple of the length desired in the hot tie plates. This is not as serious a matter in rolling tie plates as it is in the rolling of reinforced splicebars for rail joints; the length of a rail joint splicebar is such that it is hard always to get a roll of the correct diameter to accommodate the lengths required.

Rail joint splicebars have demanded considerable rolling mill ingenuity. The "continuous rail joint," Fig. 11, is rolled with flanges turned out, and in the last pass, it has been the customary practice, I believe, in some mills to bend it into final shape, while in other mills it is bent into its final shape after it has been cut to length.

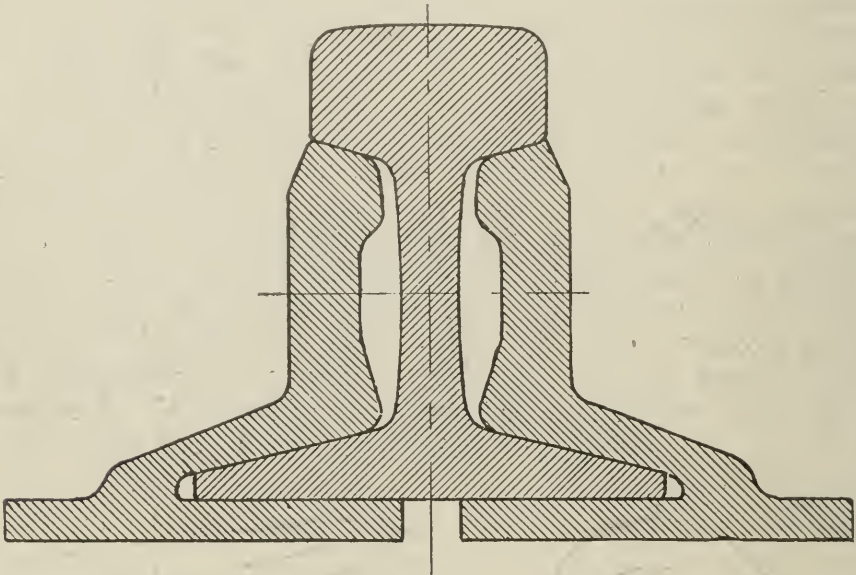


FIG. 11. CONTINUOUS RAIL JOINT.

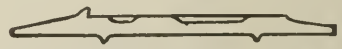
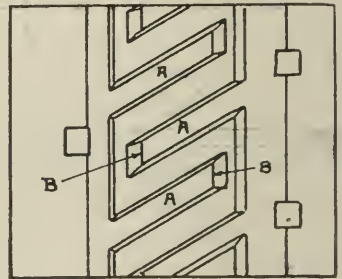
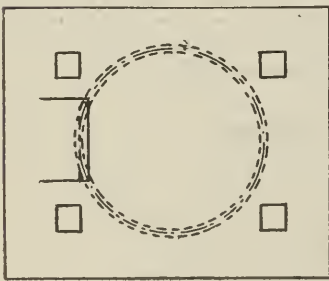


FIG. 12. TIE PLATES, THAT ARE NOT COMMERCIAL PROPOSITIONS FOR ROLLING MILLS.

We have been requested many times to roll tie plates and similar products which had projections or grooves which were not in the direction of the rolling, and when the rolls for such sections could not be commercially machined by any process with which we are acquainted, yet in a number of instances we have found other mills offering to roll such sections. This mistake is often made by the

person looking at the section desired and figuring out how the rolls could be machined without stopping to fully consider that the rolls are really the matrix for the section to be formed, in other words, that where there is a projection on the section there must be a corresponding groove in the roll.

Two types of such plates are shown in Fig. 12. The plate with the circular flange on the bottom is such that it would be very hard to mill the rolls, and when this is done, it would, in the opinion of the writer, be impossible to develop this flange $\frac{3}{8}$ in. long at the different points. Again the top side shows a shoulder which is very thick at the base, but which does not extend clear across the plate. It would be necessary to roll this clear across the plate and then cut it off through its thick portion.

The plate with the corrugated top can be made, but the rolls cannot be commercially milled to the form required, but would have to be hand chipped in a number of places. That is, the bearing surfaces "AA," which are the raised portions on the plate, are the depressions which must be milled out or cut into the rolls. The plates in question show sharp angles at line "A." This would naturally have a radius of at least one inch, on account of the diameter of the milling cutter, and the corner would have to be chipped out.

What can be done with steel of course largely depends on the quality of the material which is used and the way it is treated.

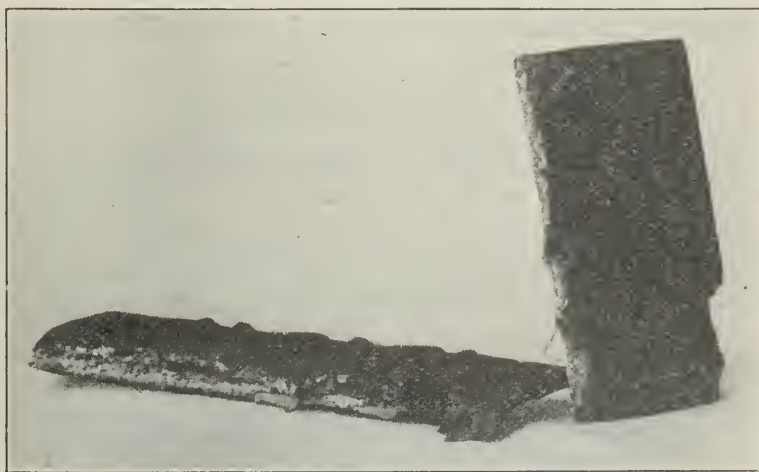


FIG. 13. TIE PLATES, ROLLED FROM SCRAP METAL.

Many times material is used because it is convenient, although it is known to be unfit for the purpose. Some tie plate manufacturers are rolling tie plates from scrap with such result as shown in Fig. 13. Such material can at best produce only a questionable product, as it is impossible to produce a homogeneous material.

For a number of years we have been asked to roll a tie plate as shown in Fig. 14, and have always said it was not a commercial proposition. The reason for saying this was that there was only a

small tonnage in sight, and the proportionate cost for special equipment and experimental work would be excessive. Now the matter is up again with prospects of a large tonnage, and we are ready to roll the plate, believing that we can put it on the market in large quantities at a price at which there will be a demand for it.

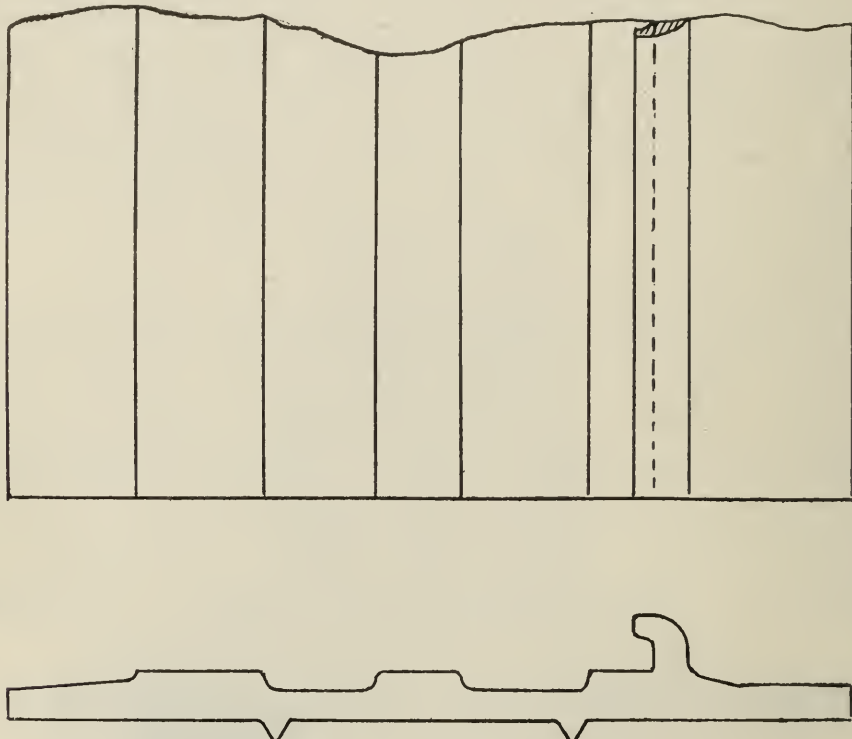


FIG. 14. NEW TIE PLATE SECTION.

Rolled sections must always compete with cast ones. This is usually not hard to do, as they can always be rolled, if at all, at prices below that at which steel or good malleable castings can be made. One of the difficult things to compete with, on account of the low price, is a so called malleable casting, that cannot safely be thrown from the cars, on account of the danger of breaking.

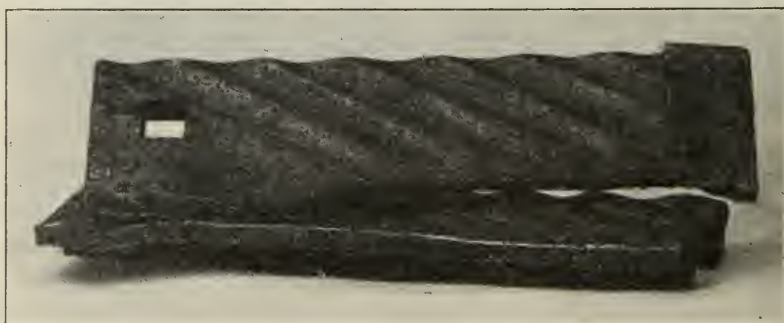


FIG. 15. MALLEABLE CAST, TIE PLATES.

When rolled sections are bought, it is very easy to make a few tests and be assured that practically every piece will come within

the range of these tests. This is not true as to malleables, and it is impossible to tell whether a particular casting is "pot metal" or malleable iron until it is tried. A number of railroads have found this out, to their sorrow.

DISCUSSION.

President Allen: The subject of the paper of the evening has come into great prominence of late years. It used to be sufficient to roll bars of uniform cross-section, beams, channels, flats, and rods, when the uses of engineering works did not require more complicated rolls. Of recent years, however, especially through the introduction of tie plates, and the deformed bars for reinforced concrete, there has come a demand for more complicated rolled sections, and the ingenuity of our rolling mills has been taxed to produce them. Mr. McKee has told us of a few of the things that have been done. The work is, however, in an experimental stage, and it is hard to predict what may be accomplished along these lines. The paper is now open for discussion.

G. F. Dodge, M.W.S.E.: On page 734 the speaker of the evening says something in regard to being unable to roll a third projection on a channel. I am wondering why that could not be rolled, taking the second method, Fig. 7, and with that having the middle projection already rolled in the form of a T, and then reducing the final flange and bending, as in the second method. Would it be possible to do that?

Mr. McKee: In giving an edging pass, the rolls are divided on the center of the piece, thus developing the center leg. If the main body of the piece is not straight, it would be difficult to hold the piece in the edging pass.

Mr. Dodge: My thought was that the middle flange would be edged and brought out to something more than the necessary height as a T, before starting to butterfly.

Mr. McKee: I think you would find that this would take so many passes you would loose the other leg.

James E. Jones: It depends entirely on the width of the section wanted. If you get it within eight inches it might be possible to put a flange on the third projection.

Mr. McKee: If the usual type of tie plates are considered, it is customary to make these inner legs quite short, in comparison with the outstanding legs. The only thing we do is to reinforce the bar and try to shove the extra metal down into the groove at the bottom, while the legs at the edge of the bar can be developed by having the rolls divided at the bottom of the legs. That is really what I meant to bring out. It is possible that, under certain conditions, the scheme you suggest might work.

A Visitor: What would be the object of that additional leg, outside of the tie plate.

Mr. McKee: I do not know. There are so many different sections coming up. For instance, the mills are asked to try to roll a door-hanger something like this "□." That can be *formed up*, but it is not a rolling-mill proposition. The different propositions that are put up to the rolling-mill, with different kinds of projections, are legion, and a great many that are being rejected today are going to be rolled next year, because the rolling-mill men can do more than they think they can do. This will be possible, also, because the larger tonnage will justify it.

S. T. Smetters, M.W.S.E.: Referring to Fig. 10; what is the pressure per square inch on the rolls? Do you have to have the metal special?

Mr. McKee: We reduce the metal from $1\frac{1}{4}$ to $1\frac{1}{8}$ in. down to $\frac{3}{8}$ in. thick in one pass, and have never broken a roll. That is all I can say.

Mr. Smetters: What is the horse power, compared with ordinary rolling?

Mr. McKee: I have not carried on experiments, enough to know. The whole thing is excessive. It cannot be a perfect bar at that, because one cannot make the reduction on the flanges that he can in the body of the plate; therefore, the metal is not as well worked as it ought to be; there is more or less rupture. We do it, but that is all I can say.

President Allen: Are any of those tie plates hot-stamped instead of rolled? Has that been tried?

Mr. McKee: It was tried years ago, by the Avery people, of Cleveland, but it is not now commercially done at all.

President Allen: Of course it might be possible, with the hot-stamping process, to produce plates that could not be rolled, but I presume that the cost would be more than for rolled tie plates.

O. P. Chamberlain, M.W.S.E.: In Fig. 9 is shown the plate bar with a great variation between the flanges, due to the slip. While I suppose I am exposing my ignorance in regard to rolling-mill methods, yet the author of the paper has said that the principle to go on, is "to work on the supposition that everything can be done until it has been shown that it cannot be done." I am wondering whether any attempts have been made to control the speed of the rolls so that both rolls will be moved alike? That is, so the rolling can be done without interfering with the pressure of the rolls?

Mr. McKee: If you refer to Fig. 10, it is the desire to make the rolls of such diameter that the controlling diameter of the top and bottom rolls would be exactly the same, so that the two will tend to make the piece travel at the same rate. In usual practice we make the bottom roll of chilled iron, because it will stand up the best,—I mean it will take the smoothest finish, etc.—while the top roll is made of steel because we find it impracticable to mill those grooves in the chilled iron roll. The steel will roughen up very quickly, while the chill stays smooth. If the outside diameter of the rolls is made exactly the same, when the rolling is started it is probable that

the bottom roll—the chilled roll—will hold the piece back, on account of the smaller diameters, where the bottom of the legs go into the roll, but as soon as the top roll gets roughened up, it may govern that speed entirely on account of its being rougher than the bottom roll. Of course that would not make much difference in the length. A variation such as shown in the last cut, does not come by being controlled by one roll or the other. The only explanation to that, is that part of the time the metal did not move at all, or that when it did move there was a slippage, and it did not go with the speed of the roll. We seldom have that happen, but it occurs sometimes when we put in a new roll, when possibly there is grease on the roll. We have had very few instances as bad as the one I showed you, but to get the true diameters of those rolls so they will work absolutely harmoniously, is rather difficult. The surface of the top roll is much different from the bottom roll, the one having the shoulder across it and the other having the flanges around it.

It is the usual rolling-mill practice to use one or another of three different kinds of rolls,—one being a gray iron casting, which is a sand casting made simply out of good charcoal iron; another kind of roll is the chilled roll, in which the surface of the roll to a depth of 1 to 2 inches is chilled; the third roll is a steel casting. The chilled roll gives the nicest finish of all; the steel roll is stronger than either of the other two, but roughens up easily; the sand roll is the cheapest of all and is easiest to turn. Each has its peculiar function to perform.

A Visitor: Referring to the German practice of rolling sections of fancy molding, I suppose one roll forms the fancy part of section and the other is comparatively plain.

Mr. McKee: In most of those moldings there is only surface work, with no real depth to the work, and instead of 60 to 70 per cent there is only a small reduction; furthermore, if a slip should occur I do not think it would make any real difference, for with the figures in one case 6 in., and in another $6\frac{1}{8}$ in. long, probably it would make no difference, but the principal reason that you would not have trouble, is that the reduction is very slight. The moldings shown are probably among the cheapest that are made.

G. T. Bunker, M.W.S.E.: I would ask if it is possible to roll sections heavier than shown? For instance, 6-in. angle-bars with flanges $1\frac{1}{2}$ in. thick?

Mr. McKee: Yes, it is perfectly practicable. They can be purchased in open market.

George M. Mayer, M.W.S.E.: Is there much of that special sheet piling made at the present time?

Mr. McKee: Yes, quite a large tonnage of the section shown is being made, and a number of other sections somewhat different, each steel plant trying to get up something different from the other one, and quite a large tonnage is sold.

President Allen: I suppose the lips on the girder rails used in this city are turned over in the finishing pass.

Mr. Jones: In some cases they are, and in other cases the grooves are put in something similar to the "Gray Bethlehem" mill. In the rails used here the grooves are put in by a side roll.

Geo. W. Brady, JUN.M.W.S.E.: Is it not possible to put the projections on the inside of the chill, so that the chilled roll as cast would be in shape at the time, and would not have to be machined?

Mr. McKee: It would be impossible to cast them true, and even if they were true it is necessary to turn them up in order to get a finished surface. It is also necessary to turn up the rolls for each dressing.

THE CHICAGO HARBOR

BY JOHN M. EWEN, M.W.S.E.

Presented September 15, 1909.

Water transportation has played a much larger part in the development of Chicago than most persons realize. While the importance of water traffic for Chicago has seemed to be ebbing during the past decade I believe a revival is in sight and that water transportation in the future is to contribute more to the progress of Chicago and the community tributary to it, than it has in the past.

Chicago, Buffalo and Duluth occupy the three positions of greatest strategic advantage with reference to water transportation upon the Great Lakes. Buffalo stands at the point of transfer between the Great Lakes and the canal and rail lines to the East. Duluth, besides being at the northwest terminus of lake transportation, is surrounded by immense deposits of iron ore. Chicago, located at the foot of Lake Michigan is possessed of a far richer hinterland than Duluth can ever expect to have. It has exceptional opportunities as a distributing and manufacturing center. The region about Chicago, in agricultural resources, is one of the richest in the world. Abundant coal supplies are not far away and the iron ore of the Lake Superior region can be brought to this area so cheaply by water transportation as to make Chicago the natural meeting place for the coal and the iron ore.

With the development of the Erie canal Chicago became the western terminus of water transportation. It thus became the greatest grain shipping center of the West. The presence of immense timber supplies in Michigan, Wisconsin, Minnesota and Canada adjacent to the Great Lakes made possible the utilization of water transportation for lumber. It was because of its location, that Chicago became the greatest lumber center in the world and the bringing in of lumber in large quantities naturally contributed to the development of manufacturing in lines in which lumber is the principal raw material.

It was the commerce and industry developed by location on the water which made Chicago the mecca for the railroads so that today this city is the greatest railroad center in the world. Chicago's supremacy as a railroad center, in other words, is indirectly due to its earlier supremacy as a water transportation center.

Even the despised Illinois and Michigan canal—the "tadpole ditch,"—has played in the past a more important part than is commonly realized. This canal in earlier days carried a large volume of traffic and was an important factor in maintaining low railroad rates to and from Chicago.

When the Lakes-to-the-Gulf Waterway shall have been completed and when the improved water routes from the Great Lakes

to the Atlantic Ocean shall be a reality—whether by an enlarged Erie canal, by the St. Lawrence route, or by the proposed Georgian Bay ship canal, or all three—Chicago will be in a position again to profit tremendously by its advantageous location with reference to water transportation.

In order to derive the benefit which is its due, however, Chicago must be prepared to take advantage of the opportunities open to it. This involves tremendous development in the way of harbor and dock improvements.

In the early days of water transportation the craft navigating the Great Lakes and even more those navigating the Illinois and Michigan canal, were small in size. They did not require deep water nor expensive dock facilities. Moderate improvement of the river sufficed to attract to this location tremendous volumes of traffic. The improvements of earlier days were sufficient to the needs of those days.

It is interesting to note that more than forty years ago the authorities were planning elaborate harbor developments. Government engineers in the "sixties" recommended the building of a harbor on the Lake Front and in furtherance of that recommendation protecting breakwaters were built. In the controversy and litigation between the public and the Illinois Central railroad over the question as to who should control the proposed harbor, the improvement was blocked. A few docks were built on the Lake Front, but in the main the project of forty years ago has been abandoned and the area in question is now devoted to park purposes.

Chicago in recent years has been losing its lake commerce. . Perhaps if the development of earlier years had been carried out as planned the story might have been different. While to some extent the commerce of Chicago has declined because of the natural falling off of the supply of some of the commodities of lake commerce—notably lumber—it is undoubtedly true that better facilities would have meant more water traffic. It is significant that the Chicago river harbor is the only one showing decline of water traffic. The movement of freight on the Great Lakes has increased tremendously in the past decade. Milwaukee, Duluth, Cleveland and Buffalo all show large increase in tonnage. The port of Chicago has just about held its own during the past ten years. Chicago proper shows a large decline. The water traffic for the port as a whole has remained constant because the commerce of South Chicago has increased by about the same amount that that of Chicago proper has fallen off.

There are signs that the city is awakening to the importance of water transportation. The vessel men and the dealers in the few commodities of heavy lake traffic, who heretofore have been waging the battle for river improvement practically alone, are now receiving the support of the public authorities and of public opinion. The appointment by Mayor Busse of the Harbor Commission was one

evidence of this reawakening. The Harbor Commission after more than a year of work upon the subject, submitted to the Council on March 1, last, a report recommending a comprehensive plan of harbor development. The city administration and the Council Committee on Harbors, Wharves and Bridges are now dealing with these various recommendations with a view to carrying them into effect as speedily as possible.

The subjects first to receive attention are those of center pier bridges and the development of docks north of the mouth of the river.

For years the street-car tunnels under the river were serious obstacles to navigation, and prevented vessels entering the river loaded to their full capacity. After years of agitation, these obstacles to navigation were removed. The center pier bridges, however, remained. The agitation for their removal, and the substitution for them of bridges of the bascule type has been carried on for a number of years. Recently some of these old bridges have been taken out and new bridges of the bascule type having a clear span of 140 feet at the water line have been substituted in their place.

The Harbor Commission was of the opinion that the bridges, instead of being 140 feet in the clear, should be 200 feet. The problem confronting the city at this time is, not only to do away with the center pier structures, but to get in their place bridges adequate for the needs of the future. The War Department has already fixed a date within which the bridges at Lake street and Indiana street must be removed. The city administration and the Council Committee on Harbors, Wharves and Bridges are now dealing with this matter with a view to making arrangements for the best type of structure that can be devised. Within a few years the policy of harbor improvement should make it possible for the largest vessels navigating the Lakes to enter the main river and its branches and traverse them for as great a distance as the interests of shipping call for.

The Harbor Commission, created by resolution of the City Council and appointed by Mayor Busse, was directed primarily to consider the question as to how much of the Lake Front should be reserved for future harbor uses. The Commission was of the opinion that extensive reservations should be made south of Grant Park, but it did not recommend the immediate construction of harbors in that vicinity. Its suggestion was, that the contemplated park improvements for that area be so carried out as to permit of later adaptation for harbor uses, if found necessary.

The Commission was of the opinion, however, that piers projecting into Lake Michigan north of the mouth of the river should be constructed as speedily as possible. These piers would be intended primarily for the accommodation of passenger and package freight boats. The passenger-carrying vessels are now doing business in the port of Chicago under very great difficulties. It is important

that the facilities for these boats be increased. With the construction of a street-car line running to the piers, the location north of the mouth of the river would be well adapted to passenger boat purposes.

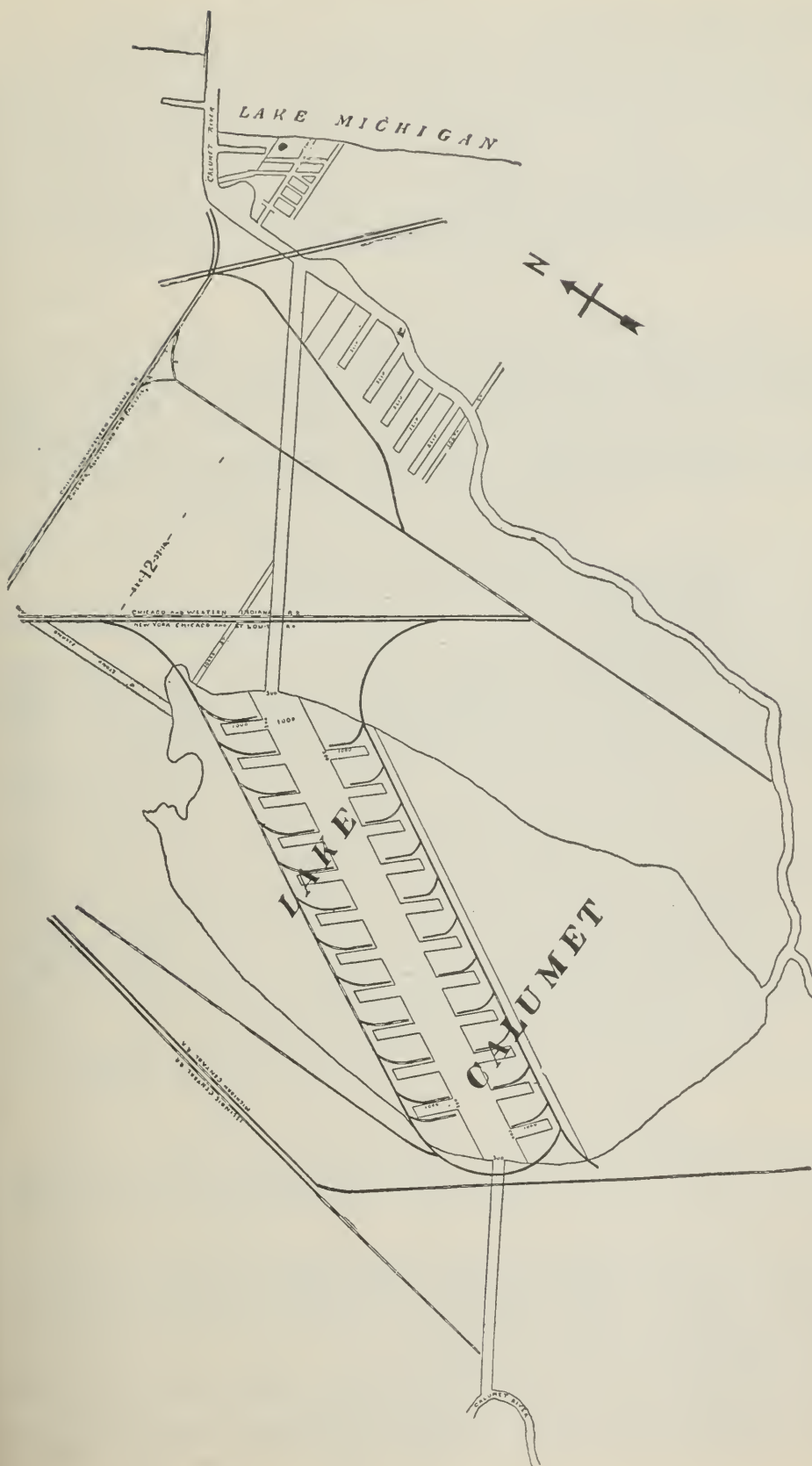
The package freight boats now have their docks at various places in the Chicago river. Most of them have insufficient room for the proper transaction of their business. New boats that might desire terminal facilities in the port of Chicago, whether for the passenger or package freight business, would find serious difficulty in securing the desired accommodations. With the construction of piers north of the mouth of the river, adequate facilities could be provided for the passenger and package freight boats now doing business in Chicago. This location probably will not provide facilities sufficient for all time to come. But the thing to do now is to provide these facilities as soon as possible, and then take up for consideration the question as to what shall be done when these piers shall be utilized to their limit of capacity.

The Council Committee on Harbors, Wharves and Bridges is now considering the questions of policy involved in the carrying out of this project. The main question is as to whether the city itself shall build and own the docks, or whether it shall allow a private corporation to construct and manage them.

While removal of center pier bridges and the construction of docks north of the mouth of the river are the two problems of most pressing importance in connection with dock matters, they are by no means the only ones demanding attention. Harbors are classified as of two kinds, Commercial and Industrial. The harbor north of the mouth of the river would be a commercial harbor. For Chicago and the area tributary thereto, what is known as Industrial Harbor Development is quite as important as Commercial Harbor Development. The branches of the Chicago river, the Sanitary District canal, the Calumet river and its branches and Lake Calumet all afford many excellent factory sites in locations having both water and rail transportation. In some cases the channels need widening and dredging. In particular, there is a project on foot for deepening and improving Lake Calumet, filling in large portions thereof, and thus providing a system of docks within a landlocked harbor that shall afford exceptional opportunities for industrial development.

The new steel plant at Gary, Indiana, means that cheap iron and steel will be available in the Chicago district for manufacturing concerns that use those products as raw materials. This should signify much for the future of Chicago as a manufacturing center.

The Harbor Commission in its report took the position that the entire area from Waukegan on the north to Gary on the south should be regarded as a single industrial community, with Chicago as its natural center. No development can take place in any part of this area without benefiting the whole. The Harbor Commission, therefore, very properly recommended that Chicago should take the leadership of the movement for improving the water transportation



facilities, both commercial and industrial, of this entire area.

If the recommendations of the Harbor Commission be carried out, and if the water terminal facilities of the community be speedily improved, it is unquestionable that the public will gain much thereby.

While the Harbor Commission was not called upon to work out any detailed engineering plans for a harbor, it did touch upon some of the more important engineering matters and recommended that they be carried out by the proper authorities.

FIRST RECOMMENDATION.

The first recommendation is that a survey be made of the dock lines on the Main river and the South and North branches of the Chicago river, the Lake Front and the Calumet river and the determination thereby of all rights of ownership. There are no surveys of this nature in existence. Those that are made, show present occupancy which do not necessarily represent ownership.

OTHER RECOMMENDATIONS.

- (a) Widening the Main river to 250 feet.
- (b) Completing the work of widening the South branch to a minimum of 200 feet.
- (c) Replacing center-pier and narrow span bridges on the Main river and the South branch with bridges having a clear span of 200 feet with straight bottom chords instead of arched chords.
- (d) Cutting off the elbow at Rush street on the south side of the river.
- (e) Cutting off the projecting elbow south of the Chicago and Northwestern railway bridge at the northeast angle of the main forks, and making a turning basin at the present forks of the river.
- (f) Straightening the river from Twelfth to Sixteenth streets.
- (g) Illuminating the river by electricity for navigation at night.
- (h) Diminishing the current, especially in that portion of the river between Lake street and Twenty-first street.
- (i) The establishment of a number of public docks on the river situated at localities convenient for the distribution of freight.

CHICAGO RIVER (NORTH BRANCH).

- (a) A technical engineering study for the purpose of outlining a detailed plan for the progressive improvement of the North branch.
- (b) Straightening the channel at some points, especially between Clybourn and Bloomingdale avenues, at North avenue, and between Webster avenue and the crossing of the Milwaukee division of the Chicago and Northwestern railroad.
- (c) Widening to 200 feet of the North branch as far as it can be done in a practical and economical manner.
- (d) Replacing center pier bridges with modern bascule bridges without abutments extending into the river.

- (e) Dredging necessary to enable boats to reach the docks.
- (f) **Remedying** the unsatisfactory conditions at Fullerton avenue caused by a sewer opening and insufficient depth of water.
- (g) Dredging the turning basin just south of Diversey boulevard, particularly the east part thereof, to a sufficient depth to make it navigable.
- (h) An investigation of the feasibility of deepening and widening the channel now being built by the Sanitary District and known as the North Shore Canal (Wilmette cut-off), so as to make it navigable.

LAKE FRONT.

- (a) Reserving that portion of the Lake Front between the mouth of the Chicago river and Chicago avenue for future harbor development.
- (b) Constructing piers between the mouth of the Chicago river and Chicago avenue for the accommodation of passenger, package freight and fruit lines.
- (c) Reserving that part of the Lake Front from the mouth of the Chicago river to Randolph street for harbor development.
- (d) The preparation at once of a plan designed to permit the creation of a Lake Front park south of Grant park on lines which shall still make possible a future harbor development if such becomes necessary, as more fully explained in the text of this report, this plan to be prepared by experts on park and harbor improvements working in collaboration, but subject to the final approval of the City Council and the South Park Commissioners.

CALUMET RIVER AND HARBOR.

- (a) Widening the Calumet river to a minimum of 300 feet as far as the Forks.
- (b) Replacing present bridges where the openings are insufficient, with bridges having ample waterway; and requiring that hereafter all bridges shall have two openings of 100 feet or more, or a single opening of 200 feet or more.
- (c) Reserving frontage on the Calumet river for construction of public docks.
- (d) Creating an inland harbor on Lake Calumet, either by the City of Chicago or by contract with riparian owners, as seems most feasible after detailed study of the legal, engineering and financial problems involved.

I have simply touched upon each of the above items for there is not space or time to discuss them all at length. There is one matter, however, that I want to have you all understand and that is the question of river span for the new bridges. The present standard of 140-foot span came about very naturally and it was undoubtedly at the time a very wise and proper step in advance. The abutments of the modern bascule bridge require about 30 feet of space along the

main axis of the bridge. The two abutments, therefore, require 60 feet. Placing the bridge and abutments wholly within the bed of the 200 foot river leaves exactly 140 feet for the clear span of the bridge. The whole structure was placed within the river banks so that the abutments would not encroach upon the land and thereby interfere with adjacent property owners. This is the type of bascule bridge now being used.

The reasons given for not enlarging the span to 200 feet in the clear are two. First, the additional cost. Second, the interference with the rights of property owners in that their holdings would face the chords of the bridge when open and always face the slots along the curb lines that are designed to receive the chords and counterweights.

In my opinion, both of these objections have been removed in a preliminary design recently submitted to the Harbor Commission, by Mr. J. B. Strauss, M.W.S.E., providing for a double leaf bascule bridge of 200 feet clear span with the foundation entirely outside of the river bed and wholly within the street ends. These abutments are of the standard dimensions required by the City and are so designed that they go under the street surface. The bridge is provided with a device that locks the two leaves together in the center so that the lower chord can act in tension and the joint at the top chords act as hinge joints. By this method, the bridge when down and locked acts as a truss and not as a cantilever. This lessens the weight and cost so that it is roughly estimated the additional cost for the 200-foot clear span will be about 20 per cent. This is a small matter and should not be allowed to interfere with the general scheme of making the river as convenient for navigation as possible.

In this design the counterweight is carried upon a central chord which extends to the full length of the abutments, the side chords extending only for the length of the bridge proper, thereby eliminating the necessity for the slots for the counterweights on the line of the side chords. In the completed structure the only slot in the street is in the middle of the street. With these two improvements it would seem that all the valid objections that have been raised against the 200-foot span are eliminated.

The Council Committee on Harbors is composed of some of the best aldermen in the Council. The work of considering the recommendations of the Harbor Commission has been commenced in earnest and it is hoped that in a very short time some tangible scheme of operation will be outlined for action by the Council. If this be done the harbor development will be carried out along the line of a general plan that in the end will give to our city a harbor commensurate with not only its present necessities, but one that will keep pace with our growth. If Chicago is destined, as we all believe it is, to become one of the largest and most important cities in the world, it should have a harbor equal to the best.

DISCUSSION.

Mr. Ewen: It may be of interest for me to refer to a letter written by Baron Rothschild at the time of the trouble between England and the United States, in 1895. You will remember that the relations became strained over the Venezuela affair. Baron Rothschild submitted to Lord Salisbury—then Prime Minister—a document, a copy of which is in Washington, calling attention to the commercial relations between the United States and England, and stating that the maintenance of these relations between the two countries was indispensable to the English prosperity. In reciting the conditions in this country, he stated that the railroads would be rebuilt; (this is now taking place). He predicted the building of the Panama Canal by our Government, and said it would bring about a revolution in the world of commerce—that the commerce running east and west would run north and south; that this country would awaken to the development of her internal waterways; that Chicago, on account of her peculiar geographical position, was destined to be the greatest city of America; that Canada would make extensive water development. The Canadian Government is today considering the building of a canal from Georgian Bay to Montreal by way of Lake Nipissing and the Ottawa River, deepening and widening the Welland Canal, to be followed by the widening of the St. Lawrence River locks and canals. He also said many other things about the greatness of our country and its future.

The great question now with us locally is, shall Chicago have a harbor commensurate with its importance and keep pace with all of this development? If not, some other great center will surely have it. It has been brought to our attention that organizations in Ohio are trying to provide a canal across from the Ohio River to Lake Erie, thus leaving Chicago out. This is not an impossibility, nor is it visionary, and unless Chicago does something to maintain its own, it is bound to lose. I touch upon all of this lightly to give you some of the factors that bear upon this subject. The question of prime interest with us is the harbor,—are we going to have one and what are we going to do? The details of carrying on all this work will have to be worked out by the engineers; therefore these questions must interest you and challenge the best effort in you.

Referring to the first recommendation, "that a survey be made of the dock lines on the main river and the south and north branches of the Chicago River, the Lake Front and the Calumet River, and the determination of rights of ownership," there are no surveys of this nature in existence. Those that have been made show present occupancy which does not necessarily represent ownership. We know that there are a great many encroachments on the river and lake, but before anything is done a survey should be made.

The next recommendation is in regard to widening the main river to 250 ft. The diagram shows just where that widening will take place.

The third recommendation is to complete "the work of widening the south branch to a minimum of 200 ft." This width was established by the Drainage Board, and is also shown in the maps herewith.

(c) Replacing the center-pier and narrow span bridges on the main river and the South Branch with bridges having a clear span of 200 ft. with straight bottom chords instead of arched chords. This is a desirable improvement. Boats that are able to navigate the river without requiring the bridges to be opened have to pass directly beneath the center of the bridges; if there is a strong wind or current it is difficult for the boat to maintain that position. If the bridges have straight bottom chords from pier to pier, instead of arched chords, much difficulty of navigation would be done away with and much unnecessary opening of bridges eliminated.

Cutting off the elbows, as recommended in "d" and "e" would make a very good turning basin at the forks, as shown in the map.

The work of straightening the river from Twelfth to Sixteenth Streets could be done at a reasonable cost at this time, because of the small development industrially at this point.

Illuminating the river by electricity would be an inexpensive improvement, and is one desired by the navigators of the river.

It is a question whether the diminishing of the current in the river between Lake Street and Twenty-first Street can be changed, some members of the Commission believing that, when the work of the Drainage Board is completed, the current will not be as strong as it is now.

In connection with the recommendation in "i" the thought was that the street-ends on the North Branch and the South Branch of the river, owned by the city, would afford facilities for the building of docks and warehouses by the city for the distribution of freight at convenient points.

In regard to a plan for improving the North Branch of the Chicago River, nothing has been done. It is very desirable that a project be worked out similar to the project that is being developed by the Drainage Board in the South Branch.

Referring to (d) under the general heading "Calumet River and Harbor," (creating an inland harbor on Lake Calumet), that is shown in the final diagram. You will see there the outline of Lake Calumet. At the north end you will see a straight channel leading to Lake Michigan, proposed by the Calumet Canal & Dock Co. This company suggests the plan of their "donating the right of way for a wide and straight canal from the Calumet River to the northern end of Calumet Lake." They suggest that the harbor work could be done in either of two ways: "Either the state, directly through its agent, the City of Chicago, might dig the harbor, build the docks and control the entire enterprise, the value of the land reclaimed by filling in the lake covering the cost of the undertaking." Or, "it might contract with the shore owners of Calumet Lake to establish a dock

line in the manner suggested and make the necessary improvements, compensating themselves for the cost of the work by the enhanced value of the land made by the excavated material in forming the channel and slips." The material excavated from the harbor and slips would be used for making land for wharves and warehouse sites.

There is one obstacle in the way, however, and that is, that the lake belongs to the state. The last Legislature was asked by the city to give the lake to the city. This bill, with many others pertaining to Chicago, did not pass, but the matter will probably be taken up again. The Mayor has recently asked the Governor to include in the next call of the Legislature the right of Chicago to build, own, and equip docks, and in general to do everything necessary to develop its harbor.

J. W. Mabbs: What is the recommendation of the Commission about dock equipment?

Mr. Ewen: The recommendation is that there shall be sufficient equipment to take care of the business.

Mr. Mabbs: What different companies control the different docks?

Mr. Ewen: The docks, with few exceptions, are owned by private capital. At the port of Liverpool a boat may, by paying the regular charges, sail in port unannounced, have all the privileges that the Cunard or any other line may have, and all the advantages of economic operation. The boat may unload and load and never go back again to that port. In Chicago, provision must be made in advance by ownership of docks or by lease. A tramp boat would have a very hard time getting in and out.

The whole port of Liverpool was built up without any cost to the city of Liverpool. "The control and management of all the docks at Liverpool are vested in a Public Trust called The Mersey Docks and Harbour Board. This Board consists of twenty-eight members, of whom four are appointed by the Crown, and twenty-four are elected by the dock ratepayers. A candidate must pay to the Board within the year immediately preceding his election, rates in respect of ships or goods of not less than £25. The taxes were made as low as possible, for Liverpool has to compete with Glasgow. A sinking fund was accumulated, and \$150,000,000 have been spent in fifty years in Liverpool from excess in receipts.

At a meeting of the Mersey Docks and Harbour Board in April, 1907, in "discussing the growth of commerce, the need of a larger dock was seen, and at that meeting they voted an expenditure of \$16,000,000 to provide a dock with berths for four ships at once, with lengths up to 1,100 ft. and 120 ft. beam; and with quays, sheds, railway tracks, and driveways accompanying." This was done quietly, without any excitement, and without "asking permission or approval or support of anybody, except a parliamentary permit for general harbor improvement. They had the money in the bank and voted to have the improvements made. That work is

December, 1909

now being carried out, and the ease with which the matter was handled made a great impression on other cities. Other ports of England and on the Continent are expending large sums now. Eighteen or twenty European ports have spent from \$20,000,000 to \$140,000,000 on their ports, and are still spending more money on greater improvements.

London, like Chicago, has been steadily losing in its commerce, but has recently formed a Harbor Commission. The port was originally controlled by seven different bodies representing private capital as well as municipal ownership. They worked at cross-purposes, competing with one another for trade, and gradually drove the business to other ports. This last winter all of these interests were united under one Harbor Commission. It has been said by high authority that this consolidation under one control was the most important event, commercially, that has ever taken place in London. It is now estimated that London's water commerce will be recovered.

Richard Price Morgan, M.W.S.E. (by letter).: Not being able to be present tomorrow evening, I desire to ask Mr. Ewen the following question, having carefully examined and considered his paper before our Society:

I understand by the paper, that you leave an open gap transversely through the outer harbor, a mile in width, with broad angles of lake exposure focal in a degree at the mouth of the river. Across this exposure, marine movement between the outer harbor and the river, to and fro, must take place. Will you kindly state what the considerations are that justify such a serious break in the commercial facilities of the river and lake front (Chicago Harbor)?

Mr. Ewen: Referring to Dr. Morgan's letter, the developments may never extend south of Sixteenth Street. If, after developing docks at the mouth of the river from Chicago Avenue to Randolph Street, the demand still is for more docks, there is no other place to go but south of Sixteenth Street. In that event we must skip Grant Park, as we cannot hope to build docks in the park. The outer new proposed breakwater could be continued south as far as Jackson Park, if necessary, leaving the harbor at Grant Park for yachts and pleasure craft the same as now.

R. J. Mershon, M.W.S.E.: All the docks that I have been acquainted with, present an unsightly appearance generally, and it seems to me if we have docks along the lake front, the appearance of the lake front would be a great deal worse than it is now, and it is bad enough at present.

Mr. Ewen: Dr. J. Paul Goode has traveled extensively among foreign ports, and has given an illustrated lecture which is very instructive on the subject of harbors. From this lecture one can see that the artistic side of port development has not been neglected. I have visited many foreign ports, including the docks of Liverpool, and it was a great pleasure to find such substantial, fine looking buildings everywhere. Chicago has grown heretofore "any old way," but

now we want to clean up, change, and pay more attention to appearances, all of which can be and should be done.

Mr. Mershon: In spite of all the talk about getting rid of the smoke, I occasionally hear it stated that the smoke is as bad as ever.

Mr. Ewen: The tendency now is to improve things, but it must be remembered that we are only seventy-five years old. When London was only seventy-five years old it wasn't safe to go out after dark.

Mr. Mershon: I would like to ask, for information, if anything is being done by the Federal Government, or by others, to maintain the present level of the lake? I was brought up in Michigan and around Lake Michigan, and have been told by engineers here in the city and by intelligent men living in Erie, that the lakes are at least 24 in. lower than they were forty years ago; (some say 30 in.) and that they are getting lower on account of the water that is being diverted from them.

Mr. Ewen: That is a question which concerns more particularly, the waterway development. Mr. Randolph, who is an authority on that matter, can probably answer that question.

G. A. M. Liljencrantz, M.W.S.E.: I have found no mention of what has been done heretofore for the improvement of the rivers and harbors in this District, and it seems to me appropriate to show what has been expended by the U. S. Government for this purpose up to the present time (Sept. 1, 1909). These expenditures have been as follows:

Chicago Harbor\$2,552,039.85

CHICAGO RIVER:

Dredging River and Branches in 1896-98
(17.0 ft. depth)\$189,351.75

Widening at narrowest bends and dock
corners in 1899-01 (including cost of
removed land and building of new
docks) 203,788.68

Construction of 2 turning basins (includ-
ing land purchased and building docks) 464,900.22

Dredging and rock excavation (North
Branch and South Fork) in 1908-09
(21.0 ft. depth) 458,469.05

Salaries and other contingencies 24,276.95

Total 1,340,786.65

CALUMET HARBOR:

Dredging, piers, and breakwaters 1,479,788.48

CALUMET RIVER:

Dredging and rock excavation 860,503.79

Grand total\$6,233,118.77

December, 1909

J. W. Mabbs: My father was deeply interested, some years ago, in the idea of making a sea-wall about two miles from the shore, just inside of the water-cribs, and making a harbor which would extend all the way from Evanston to the Calumet River, allowing the boats to come in at the north and south ends of the harbor. That would make a harbor twenty-four miles long and about two miles wide. In connection with that scheme, the idea was to put in docks along the sea-wall and make the dockage on the outer edge of the harbor, instead of on the shore line, and connecting them by underground tunnels with the different railroad systems. This would give a harbor with dock facilities that would take care of Chicago for the next few hundred years, and the scheme would not in any way interfere with the park systems, nor with the beauty of the city.

Mr. Ewen: With thirty-five feet of water out in the lake, the chances are it would be difficult to induce the Government to build such a breakwater.

Mr. Mabbs: The idea was to take the stone that came out of the drainage canal, and make a stone embankment, which would not cost much more than an ordinary railroad embankment, and being made with a gradual incline on the lake side, no amount of "sea" would ever wash it away. There is sufficient stone on the banks of the canal to build that breakwater all the way from the Calumet River to Evanston, and it could be done at comparatively little cost.

Mr. Liljencrantz: "Comparatively little cost" is rather indefinite, and I can not help wondering how many millions of dollars it would require to make the cost appear to Mr. Mabbs as comparatively great.

C. F. Loweth, M.W.S.E.: I am glad that the recommendations of the Commission kept in view the extension of the park system along the southern part of the city, for I believe it would be a great mistake to put in a harbor that would prevent the people from having free access to the lake at a great many points. I live in Hyde Park, and there is no breakwater along the front of the lake at that point; it is a great pleasure to go out there and watch the lake. The people in that vicinity would be greatly disappointed, I am sure, if, in going out to the lake shore at Jackson Park, Hyde Park, and other points, they could not see out any further than a mile or two.

J. C. Bley, M.W.S.E.: I would inquire as to the matter of width of the river and clear channel. As I understand it, you ask for a channel of only 200 ft. and at the same time you ask for a clear span of a bridge for 200 ft. Boats have the privilege, I believe, of tying up anywhere on the river, and there is the possibility of a boat being on either side of the river between the bridges. It seems to me that it makes an unjust burden on the city for bridge building.

Mr. Ewen: Of course the Chicago River will be a highway to the drainage canal proper and the deep waterway, and while it is true that boats will tie up, it is also true that very few will tie up along that highway for any length of time. The argument might be

used that obstructions on State Street to within 300 ft. would not impede traffic, still those obstructions would interfere with traffic. If some of the boats tie up on the river on both sides, your argument would be true, but that probably would seldom happen. The idea is to have that channel as clear of obstructions as possible to form the north entrance to the deep waterway.

Mr. Liljencrantz: Is the idea, then, that the South Branch would not be used at all for docking purposes? If that is the case, we should have the full width. There are, however, a great many corporations that desire to use their dock frontage, and in such cases the abutments will act as protections for their boats. That is one reason why I consider that it would be better to have 140 ft. span than 200 ft. span. If the river is 200 ft. wide, even at bridge draws, and there are vessels lying at the docks, there would be danger of collisions with these vessels and those passing down with the current, while abutments would offer some protection.

Mr. Ewen: If the abutments on the river are built with 30 ft. projections, they are there for all time. But while the boats in tying up at the docks offer an obstruction, still they are not there for all time. Again, the abutment sticking out 30 ft. creates a current in the river. A boat while waiting in the channel for a bridge to open, might get swung out of place and it would take ten minutes for the boat to get straight again. If the boats tie up at the dock, of course you have an obstruction, but the boats are not always there.

Mr. Liljencrantz: Is not the idea now to plan for the future, when there might be boats tied up on both sides?

Mr. Ewen: We are dealing with a narrow river, and want to make all that width as available as possible. It is a question of convenience and facility. All these things facilitate navigation, and when facilities are good, more boats come in.

Isham Randolph, M.W.S.E.: Do you know of a single instance on record of a boat striking the abutment of a bascule bridge?

Mr. Ewen: I was surprised one morning to notice that the south abutment of Wells Street bridge had been knocked all to pieces. It looked as if it had been struck by an eight-inch shell.

Mr. Liljencrantz: Wells Street bridge is not a bascule bridge. If the South Branch of the river is to be used exclusively as a highway, all vessels coming in would have to pass through a great many bridges before they come to the place where they would make their dockage, and frontage owners along this highway would undoubtedly insist upon the right to use their docks.

Mr. R. C. Huston, M.W.S.E.: Can you give us an idea of the cost of other ports, as compared with Chicago, on a tonnage basis?

Mr. Ewen: Duluth has a lake commerce of about 20,000,000 tons, while Chicago has 11,000,000 tons. I suppose Duluth has spent six million dollars on its harbors, while Chicago has done very little.

H. J. Fixmer, JUN. M.W.S.E.: I have made a study of a system of improvements designed to relieve traffic congestion in Chicago, and

am of the opinion that the wisest thing to do would be to construct a ship canal at about Fourteenth Street, connecting the South Branch of the river with Lake Michigan. This canal would be less than a mile in length, should be at least 200 ft. wide, and would carry 27 ft. of water. This is obviously a direct extension of the great Drainage Canal.

It is proposed to condemn all land lying between Twelfth and Sixteenth Streets, and lease the same for dockage, storage, freight transfer, and commission trade. A lake front harbor would be built at the mouth of the canal, with sufficient slips to accommodate the railroads having ready access thereto. By reason of having an adequate outlet south of the congested business district for the future traffic along the South Branch of the river, Drainage Canal, and future Gulf Waterway, we would be enabled to make all bridges between Lake Street and Twelfth Street on the South Branch fixed, of such span and height to accommodate tugs and lighters. Thus two rivers would have been created and the traffic on the main river reduced probably more than half. Also, this canal affords a needed source of supply of water for sanitary purposes, permitting the admission of ample water without creating undue currents, which even now interfere with navigation. The aid of the United States Government would no doubt be enlisted to build this waterway, since it would be an aid to navigation. If the Gulf Waterway is ever completed the government might insist on the construction of such a channel.

By reason of eliminating that part of the tortuous river between Lake and Twelfth Streets for other than a sewerage channel, or waterway for tugs and lighters, we have virtually "annexed" the whole west side of Chicago to the central business district. This is important for reasons affecting other sources of congestion than waterway and harbor.

The location of this canal at Fourteenth Street has advantages from an artistic standpoint. By tracing it on a convenient map it is seen at once to make a symmetrical plan; with the suggested "Civic Center" at Halsted and Congress Streets, about equidistant from the main river and this proposed canal. This canal, while it would require the railroads in the vicinity to abandon or readjust their terminals, now inadequate, would open up the great territory along the Drainage Canal, where extensive factories and railroad terminals could be constructed. This extensive dock property cannot be developed until an outlet is provided, with fewer than the nineteen bridges now existing north of Fourteenth Street.

Of course there are objections to this plan, but these objections, when analyzed, are only selfish and sentimental. It is to the city's interest that the congested freight terminals be moved elsewhere, and the transfer of package freight be made by lighters, with convenient docks at the foot of various streets. The canal at this point would greatly develop the adjacent district for commercial purposes, and could hardly prove objectionable to "South Siders," since their

means of entering the downtown district will soon be by way of the subway.

In conclusion I will say that it is of vital importance to Chicago to develop an *inland* harbor,—a harbor accessible to railroads, factories, teaming, shipping, and labor—for it is these things that have made Chicago what it is today.

Mr. Ewen: That matter is covered exhaustively in the harbor report.

Mr. Liljencrantz: General Ernst recommended the establishment of channel-lines for the Chicago River, as the city of Chicago has never established any complete system of such dock or channel-lines in this river and its branches. But the Department ruled that the expense, including condemnation of land, would be prohibitive. In the Calumet River the Government has established channel-lines, and has dredged to a depth of 21 ft. up to 122d Street, and from there a depth of 17 ft. up to "The Forks" at Lake Calumet. No encroachments on the channel are ever allowed.

Mr. Ewen's paper stated that there are no surveys in existence of these two rivers, for the purpose of ascertaining proper ownership. A survey of Calumet River was made in 1881 by myself, and the channel-lines were established definitely by the Secretary of War. The right-of-way was deeded by the respective property owners, and the title to each tract of land was examined by the District Attorney. Thus the owner of every part of the frontage was ascertained. Since that time a great many transfers have naturally been made, but in a general way we know the owners of most of the properties. Work is now in progress on channel-lines to be established by the Secretary of War above "The Forks," as soon as the deeds from all the property owners have been received. We are expecting results almost any day. Five turning basins are to be built; one has been made near Ninety-third Street, where a boat 650 ft. long can turn, and the deeds have all been made out for a turning basin at "The Forks." The money has been appropriated for that and for the three others.

Many valuable recommendations have been made by the Harbor Commission, but so far I have not seen any estimates of the approximate cost of carrying them out. Have any such estimates been made?

Mr. Ewen: As stated in the report, the Commissioner received only ten or twelve thousand dollars to carry out what work has been accomplished. None of the members of the Commission received any salary for services; no engineers were employed and there was no way of obtaining estimates. We had expected to make a number of other recommendations, but as the cost would run up to many million dollars, it was thought unwise to make them. Three members of the Commission were engineers and went into the matter of cost as far as possible, and it is believed that none of the recommendations made by the Commission are prohibitive. We have now asked the City Council for money to do the very thing you have suggested,—to make the surveys and establish data from which we can esti-

mate the cost, especially with reference to the question of straightening and widening the main river and South Branch.

Mr. Liljencrantz: If the city is to pay for these improvements, it will undoubtedly take a great many years before it can be done. I remember that at a public hearing in the Government Office, concerning the removal of Fuller Street bridge, the City Engineer, when called upon for his opinion, admitted that he considered it necessary to remove this obstruction at the entrance to the South Fork, which has been lately improved by the Government at a cost of more than \$208,000, making it 23 ft. deep below city datum. At the same time, however, he said he was sorry that this was impossible, as the city did not have the money. Major Rees asked what it would cost, and was told about \$4,000.

President Allen: The city is in hopes of having the money for the suggested improvements raised on a bond issue.

Mr. Liljencrantz: Mr. Ewen made some remarks about a 100-ft. draw at Kinzie Street, and wondered whether this width was to be the standard for the North Branch. The reason for that width was this: the vessel owners (a great number of them) were called together at a meeting and were asked for their opinion. They unanimously agreed that, as only a 100-ft. channel could be had at an early date, under existing conditions, this would be far better than waiting many years for something better.

Mr. Ewen: That has been the history of everything on the river—working from hand to mouth.

Mr. Mershon: I would ask if those docks are necessary before the Lakes-to-the-Gulf Waterway is built?

Mr. Ewen: I believe that if the docks at the mouth of the river had been built ten years ago, our tonnage now would have been much greater than it is. We are having a great deal of discussion on the deep-waterway question, but nothing has yet been done. Our water commerce is constantly diminishing, while Chicago is growing. If we talk about the matter for ten years longer, we will lose still more heavily. If we had acted ten years ago, I believe our tonnage today would have been 20,000,000 tons instead of 11,000,000 tons. It will be a great misfortune to Chicago if she waits any longer.

L. K. Sherman, M.W.S.E. (by letter): What I have to say regarding Chicago harbor plans is simply my opinion, but that is based on some years of engineering experience and history more or less associated with the Chicago River and the Calumet region.

The Harbor Commission has compiled valuable and essential data upon which any harbor schemes must be worked out.

The recommendation made by the Commission is not so valuable. They have recommended three projects for harbor development: The Chicago River, the Lake Front, and the Calumet region. This threefold recommendation is equivalent to no recommendation at all.

The solution of Chicago as a harbor depends on prompt action concentrated upon one main project. I favor the Calumet project as outlined by the Commission. Why?

Any improvement of the Chicago River to make an effective harbor must be radical. It involves the purchase of large tracts of valuable land, the uprooting of industrial establishments, the moving of extensive railroad yards and the accompanying delay of years of condemnation litigation.

Why spend millions in buying out vested rights and uprooting valuable properties? Money so spent in removing obstructions is of no direct utility in creating a harbor. The same money applied to the Calumet project would be available for immediate harbor purposes, dredging, dock work and land reclamation. It has devolved upon me in connection with sanitary projects to make a number of estimates of cost of canal work, both in the Chicago River and in the Calumet region. In that connection this phase of the question has been vividly thrust before me.

The least expenditure to produce the best result is the first consideration of the business man and the tax-payer. In engineering work a careful comparison of estimated costs with the results to be obtained should be the fundamental principle governing the design. If the Harbor Commission applies this principle to the three proposed harbor schemes, I believe it will reverse the order in which the proposed schemes have been presented and will place the Calumet project first.

A short time ago I made a boat trip on the St. Mary's River. Two things impressed me. The great number of vessels, most of them steamers of 400 to 600 ft. in length, forming a continuous parade of the entire St. Mary's River, and the small number of such vessels which had the Chicago River for a home.

The Chicago River was adequate in the day of the lake schooner and served a valuable purpose, so did the "tadpole ditch." The commerce of the Chicago River is declining, the commerce of the Calumet, a Chicago stream, is growing. Let us assist nature in the development of the Calumet.

The point has been raised that the value of the cargo should be considered in the harbor location. I do not think this an important feature. It would not require any extensive harbor if all the gold, silver, and silks in Chicago were brought in boats, though the value of such cargoes might exceed the value of coal, iron and wheat, which require large harbors.

C. R. Dart, M.W.S.E. (by letter): The writer will not attempt a general or lengthy discussion of the author's most interesting paper, but will consider from an engineering standpoint, including the question of cost, that part of the paper relating to bridges over the Chicago River.

The Harbor Commission has recommended that all bridges over the main river and South Branch be so constructed as to provide for a 200-ft. clear channel and with straight bottom chords instead of arched chords. There is no question but that the first mentioned feature, from a standpoint of flow for drainage, and both features

from the standpoint of navigation requirements, are desirable, and if they are feasible and can be provided at a reasonable cost, will be favored by everyone concerned in the welfare of the city.

In the recommendation as to the length of spans, there is no qualification whatever on account of limiting conditions at any bridge site, and it seems possible that this recommendation may have been made without a full study of the river at all points where bridges exist. Various civic associations have, from time to time, passed resolutions demanding 200-ft. channel bridges, without considering the practicability of their construction, and with little regard for their probable cost. It is the writer's understanding of the demands of these associations, and of the recommendations of the Harbor Commission, that the entire 200-ft. width of the river between dock lines shall not be obstructed by any part of a bridge, or the parts collateral thereto, which means that the faces, or what are ordinarily the bridge protections, shall be coincident with or shall be back of the dock lines.

The writer thinks that he may safely say that it is impossible, or at least impracticable, to replace *all* bridges over the South Branch of the Chicago River with bascule bridges that will fulfill this requirement for a 200-ft. clear width of channel. There are but few locations where what may be called a 200-ft. channel bridge will provide a 200-ft. clear channel for navigation, since but few street crossings are at right angles to the river, and in some cases the skews of the crossings are so extreme that the length of spans required are beyond the practical limits of bascule bridge construction. The most pronounced skews occur where railroads cross the South Branch of the river.

For illustration, the C. T. T. Railroad bridge near Taylor Street is a Scherzer rolling lift bridge of 275-ft. span, centers of front bearings, the longest rolling lift or bascule span in existence the writer believes, and an unwieldy one to operate, yet the skew of the crossing is such that there is afforded but 120 ft. clear channel for navigation. To obtain a 200-ft. river this span must exceed 400 ft. in length, which seems rather beyond the limits of possibility for any structure of the bascule or movable type. This same condition of extreme skew exists at the crossing of the Illinois Central Railroad near Sixteenth Street, and of the Pittsburg, Ft. Wayne & Chicago Railroad at Stewart Avenue south of Eighteenth Street.

Referring to the highway bridges, there are several of these located at points where streets cross the river at a considerable variation from a right angle. Twenty-second Street bridge is a 216-ft. span, Scherzer through type, affording but 140 ft. clear channel for navigation and, because of its length, it is also somewhat unwieldy to handle. For a 200-ft. clear river, a bascule span at this point must exceed 300 ft. This great length is a serious matter on account of the great width of the leaves, the heavy floor, and the large surface exposed to the wind when the leaves are raised. At Canal Street, at Loomis Street, and at several other street crossings somewhat

similar conditions exist, and where the distance between bascule bridge protections, if built parallel with the fronts of the abutments as in a right angle bridge, would exceed 250 ft.

Now as to the question of cost. If the added expense of actual construction of bridges providing a clear channel width of 200 ft., or as near this width as is practicable from a construction standpoint, was the only element to be considered there might be less objection to building the longer spans. The cost of the substructure and superstructure of a 200-ft. bridge crossing at a right angle has been estimated to be ordinarily not more than fifty per cent in excess of the cost of a 140-ft. bridge, unless, because of the greater span, buildings must be supported during construction of the abutments. As a matter of fact, however, the element of property damages enters into the question of ultimate cost of these structures, as does the time necessary to adjust such damages. While this question of property damages may possibly be solved in certain cases by the design mentioned by the author, or by other designs, conditions vary so much at the different sites that no one design can provide a general solution for all locations on the river. The writer does not propose to enter into a discussion of any particular type of bascule bridge, nor of the merits of the different types, patented and unpatented, but it has been his experience that practically all types now in use can generally be modified and adapted to fit the same conditions, although possibly not equally satisfactory or with equal economy. With favorable site conditions no type is more satisfactory than the old reliable trunnion bridge.

It may be stated that the space occupied by the abutment of a bridge will not necessarily be a measure of the damages to adjacent property. What is really of importance is the space occupied by the bridge back of the dock line, either *above* the floor in certain cases, or *below* the floor in other cases. Up to the present time no bridge has been constructed on the Chicago River having a depth of less than 47 feet from face of the protection to the rear of the space occupied by the bridge, either open or closed, and it is extremely doubtful whether a bascule bridge can be designed affording 200 ft. clear channel for navigation that will not occupy 47 ft. or more either above or below its floor. As far as the abutment itself is concerned, in certain designs it can be placed within a space of 20 ft. back of the face of the protection.

The main Chicago River is at present considerably in excess of 200 ft. in width where bridges occur, and spans allowing only 200 ft. clear channel can probably be constructed without great attending property damages. On the South Branch, however, north of Twenty-second Street, there is probably no existing bridge at the site of which the property damages may not become a serious matter if a bascule bridge is built that will be entirely behind the dock lines when the leaves are in the open position.

The recommendation of the Harbor Commission calls for straight

December, 1909

bottom chords, which requirement indicates through spans with the trusses above the floor. To cause the least property damage due to obstructing the fronts of buildings above the street level with the leaves in any position, the leaves should generally be of the deck type, necessitating arched lower chords. The fact that there are no slots in the floor or street along the curb lines does not necessarily mean that the building fronts will not be obstructed in an objectionable manner when the bridge is open. Again, where the space back of the dock line is occupied by railroad tracks, some of these tracks must be abandoned or the design must be such that no movable part will drop below the clearance line above such tracks. This means leaves of a special design of "through" type, and may require difficult and expensive construction to support the bridge over the tracks. Where tracks occur close to the dock line on one side of the river, and there are tall buildings on the other side, the situation is still more complicated and the troubles are multiplied.

Examine the river from Randolph Street to Van Buren Street and you will find tall buildings along the east dock and immensely valuable railroad property along or closely adjacent to the west dock. To minimize property damages for 200-ft. channel bridges, conditions on the east side indicate deck leaves with arched lower chords, and on the west side require through leaves carried by through fixed spans crossing the tracks, below the floors of which spans the rear ends of the leaves must not dip. These fixed land spans must be carried by piers located generally on the railroad property back of the dock line. The Sanitary District of Chicago has paid nearly \$2,500,000 for a narrow strip of land extending from Randolph Street to Van Buren Street, and to occupy another strip along this beach, or to obstruct tracks on same, would probably entail a still greater additional expense. On the east side of the river other problems must be met, one of which is raising the inclined approaches to the bridges, with additional property damages resulting therefrom. The construction of abutments in the streets between high buildings having floating foundations, or resting on a few piles reaching barely to the level of the bed of the river, may also add very materially to the expense of the improvement.

From Van Buren Street to Eighteenth Street the above mentioned conditions are reversed, and important railroad tracks will be found close to the east dock line. At Twelfth Street an inclined approach adjacent to and parallel with the west dockline affords access to important railroad yards to the south. This incline can not be moved without disturbing tracks and must not be obstructed by the heel of a leaf or cut off when the leaf is raised. Railroad tracks exist close to the east dock line as at other bridges within this stretch of the river. To obstruct the track on the east side at Harrison Street, Polk Street, or Taylor Street will be to depreciate enormously the value of the east dock property north of such streets, and any abutment or pier placed behind the dock line can hardly fail to be an obstruction.

In view of the conditions that must be met, even assuming that bridges affording a 200-ft. river are practicable, the expense incidental to their construction will certainly be very large. Before work can be commenced at any site, legal questions must be settled or delays may occur during construction due to injunction proceedings, pending the settlement of which the public may be deprived of the use of any bridge, old or new. Where railroads are to be ousted the legal questions may not be adjusted until final decisions are rendered by the court of last resort, and obstructive litigation may extend over a period of years. It is manifest that not more than one bridge can be built at a time in any one locality because of the inconvenience to the public, and with all the preliminary questions to be settled no one now alive would probably see the completion of the project in its entirety.

Since it is impracticable to provide a 200-ft. clear channel at *all* bridges, and will be very difficult or costly to provide this at many other bridges, in place of the recommendation of the Harbor Commission calling for 200-ft. bridges at every point, the writer would suggest, for the South Branch, that more feasible project of building spans as long as possible without undue expense or protracted delays, such spans to provide never less than 140 ft. clear channel where the river is straight, and at bends extend the spans so that the convex dock lines will be practically unobstructed. If litigation is necessary, with its consequent delays, it had better occur at these vital points rather than at locations where there is less or no great necessity for the wider opening.

The foregoing discussion is predicated upon the idea of constructing bridges of the double leaf bascule type. There is another type of structure now forcing recognition from engineers, the vertical lift bridge, which in its modern simplified form, has some peculiar advantages. In the first place it is economical, costing in long spans probably less than bascules of equal channel opening, may have straight bottom chords, and the towers can be supported by fixed spans over railroad yards. It can often be built while the old span remains in use for traffic, and the only interruption to traffic may occur while the old bridge is floated away and the new lift span is floated or dropped into place. It solves, in a very simple manner, the problem of providing two decks necessary where an elevated railroad crosses on a highway bridge. The towers of a lift bridge can be skewed so as to afford the maximum of channel with the minimum length of truss, and there is nothing impracticable, constructively or for operation, in a span of upwards of 200 ft. measured along its center line. To lift and lower quickly a span of 400 ft. or more in length, however, such as may be necessary to provide a 200-ft. channel at railroad crossings, is another matter.

The writer does not wish to be understood as advocating in this discussion that vertical lift bridges be used, thus lining the river with towers 190 ft. or more in height, nor does he consider this type satis-

factory in many respects nor a cure for all of the difficulties hereinbefore mentioned as incidental to the construction of 200-ft. bascule bridges. It is hardly to be imagined that any property owner will be delighted with a tower extending above the roof of his building in front of his windows. In appearance this type generally will not compare with the bascule bridge, and particularly that with the arched lower chords condemned by navigation interests. This arched type was adopted originally because its lines were most pleasing, its bracing most effective, and its construction generally accomplished with economy.

There is a form of the bascule bridge in common use for railroad bridges, and which is preferred for such where the length of span is not excessive; namely, the single leaf bascule. This form may possibly be feasible for a channel width somewhat more than 140 ft. and, on account of the small support necessary at the far end of the leaf, it will meet almost any condition on the *far* side of the river. Its abutment and heel must be unusually large, however, and if located adjacent to valuable property the damages may be in proportion. The leaf will be very heavy and unwieldy to operate, and in the case of a highway bridge of the full width of the street the floor area exposed to the wind is somewhat appalling.

The burden of delays at bridges, delays both to the public and to the navigation interests, is already very great, and to obstruct the Chicago River harbor and the deep waterway with heavy, cumbersome structures, slow to move or dangerous to operate rapidly, can not fail to increase this burden, and to that extent defeat the end in view.

No man can foresee all possible improvements or new adaptations of movable bridges, and probably it is presumptuous to claim that any particular condition cannot be met in a satisfactory and practical manner. Without referring to or reflecting in any way on the designs mentioned by the author, it may be said, however, that freak schemes and devices have been and probably always will be pushed forward and strongly and enthusiastically advocated by bridge designers, but which are really impracticable, or even absolutely unsafe. The movable bridge field has had a peculiar attraction for inventors, and the new conditions that are to be met will undoubtedly bring out a fresh crop of "new and valuable improvements." One tendency should most certainly be watched for, guarded against, and condemned in bridge designs,—that towards the use of light spindling supports for heavy movable spans. Slim reinforced concrete cylinders resting on rock are able to carry heavy vertical loads, even when standing in the river, but, unless of very large dimensions and thoroughly braced, cylinders alone will not properly absorb vibrations from the moving leaves or resist shocks or blows from passing vessels. The safety of these structures lies in massive supports and, with tracks to be avoided, where property will be obstructed, where first cost is of vital importance, and the selection from competitive

designs is governed by the relative cost of construction, the tendency is to always reduce the size of the supports at the expense of stability and safety.

There have been many other reasons advanced for and against adhering to the present standard channel width at bridges over the river and which will probably be presented to the society in this discussion. To avoid unnecessary repetition, therefore, the writer will not touch upon any of such points, although they have a very important bearing on the question of the proper length of spans for Chicago River.

The writer wishes to say, in conclusion, that this discussion is not presented in a spirit of opposition to the recommendations of the Harbor Commission, but to show some of the difficulties that will be encountered if the recommendations are followed, without modification, in the construction of all future bridges over the river.

A. Bement, M.W.S.E. (by letter): Mr. Ewen uses the expression Chicago harbor, but from the way the matter presents itself to me, I would prefer to say harbors; we now have three distinct harbors within the city, counting that of the Illinois Steel Company in Lake Michigan, together with the Chicago and Calumet Rivers.

I observe that the possibility of utilization of the Wilmette channel, now being constructed by the Drainage Board from Lake Michigan southwesterly through Evanston, as a harbor entrance is mentioned. If the suggestion implies its use as a harbor for pleasure craft, I have no criticism to make, but think it would be a serious error to allow the use of this channel, in any manner as a commercial or industrial harbor, because, in my opinion, the north shore should be safeguarded against encroachment of manufacturing or business to the fullest possible extent, that it may continue to be a suitable place of residence.

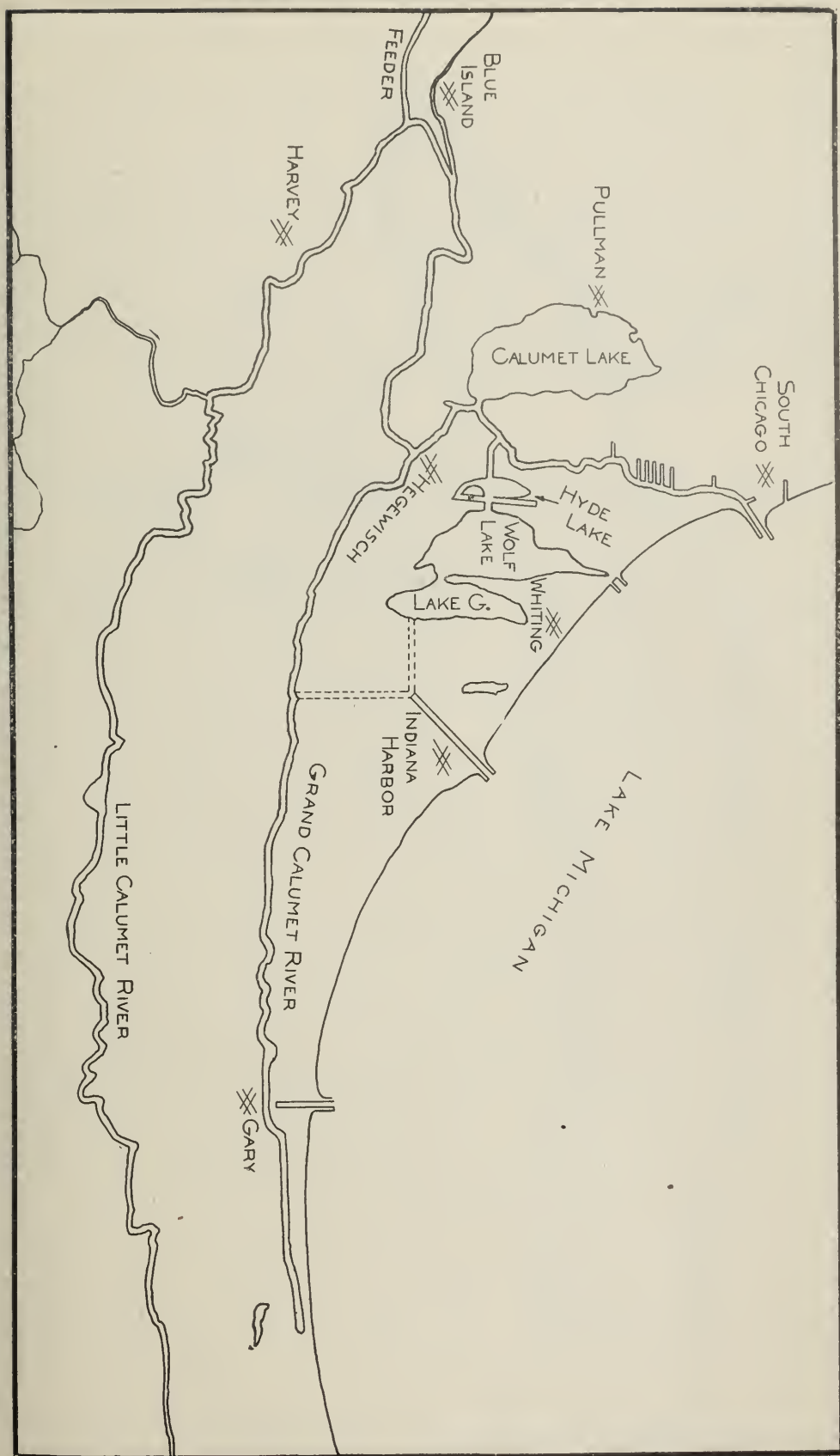
For many years, the suitability of the Calumet district for harbor purposes has been in my mind. It is a locality but little developed, where land is cheap and the opportunity for the construction of slips and docks is unsurpassed.

Mr. Ewen makes a distinction between commercial and industrial harbors. The Chicago River, I presume, would be essentially a commercial one, while the Calumet locality affords special facilities for an industrial harbor. My understanding of such, is a waterway serving a manufacturing enterprise, such as the Illinois Steel Co.'s harbor at South Chicago, the one giving direct access from the lake to ore docks. Much of the traffic in the Calumet River is of like character, and it seems to me that opportunity for the development of an industrial harbor and the promotion of industries, in the Calumet district, is a great one. It is also, in my opinion, desirable for ships to reach the loading and unloading docks by the shortest possible route from and to the lake. In this respect the Illinois Steel Company at South Chicago is at an advantage as compared with the Wisconsin Steel Company, the Iroquois Iron Company, and the Federal Furnace Company, all of which are inland.

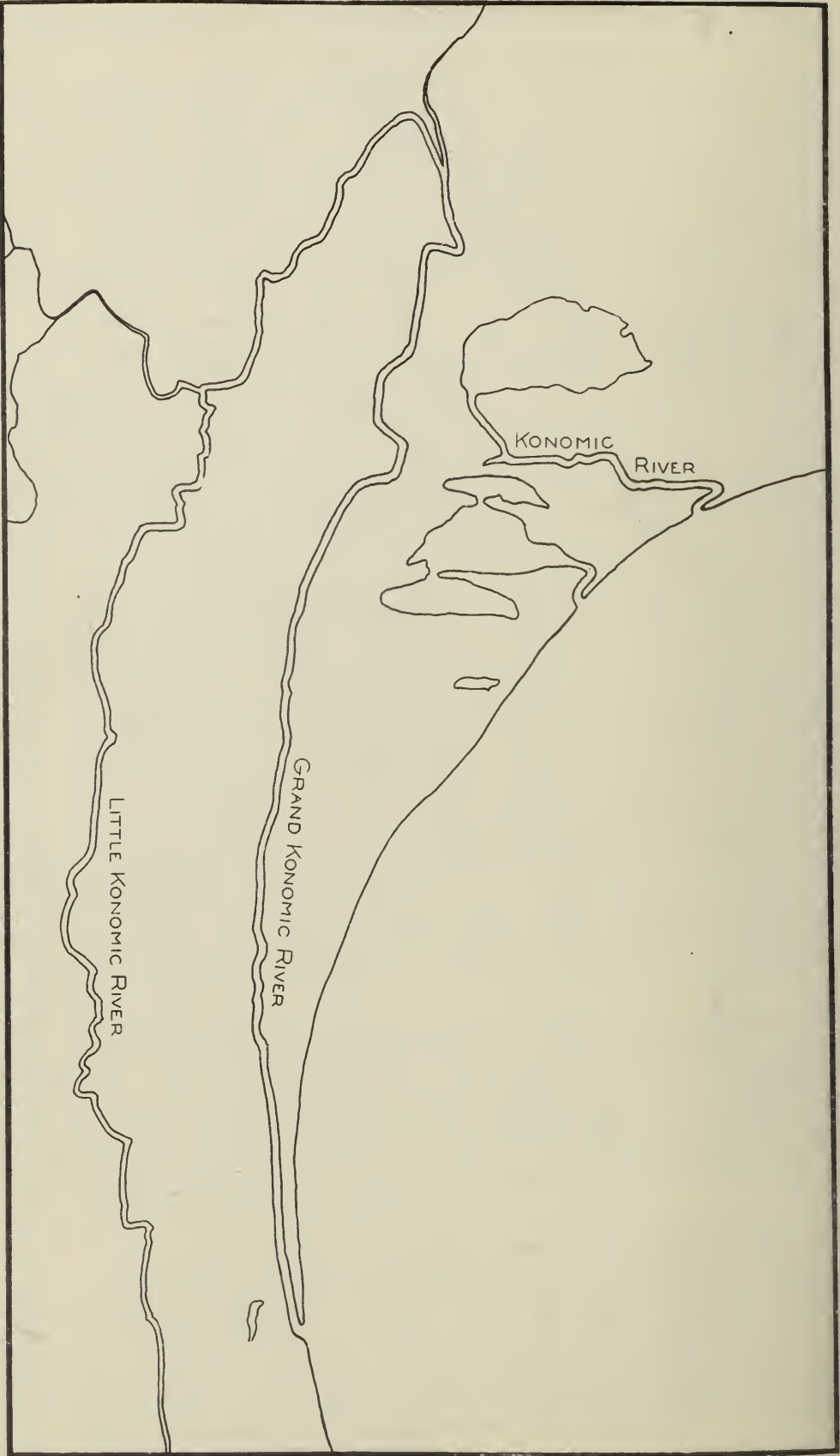
I do not believe that the industrial possibilities of the Calumet region have been properly appreciated in recent years. When the North Chicago Rolling Mill Company erected at South Chicago what has since become the South Works of the Illinois Steel Company, the record made by this plant in its early history was such as to cause it to be generally believed among iron and steel people that Chicago or, more properly speaking, the Calumet district, would become the future center of iron and steel production in America, and it was fully predicted that Pittsburg's importance in this respect would rapidly decline, and that it would be profitable for manufacturers of iron and steel to move to Chicago. Unexpected influences often change the current of affairs, however, and it is probably due to Mr. Andrew Carnegie that the Calumet district did not at the time attain the importance that was prophetized for it, as he, by the exercise of unusual business ability and foresight, strengthened his enterprises at Pittsburg by the construction of a railroad to Lake Erie and the replacement of old appliances and methods with new, to such an extent that the benefit accruing therefrom was sufficient to more than overcome the advantage of the Calumet district as compared with former Pittsburg conditions, and this gave such permanency and stability to the steel business in Pittsburg, that the danger or the prospect of the Calumet locality becoming the center of production was practically forgotten. I have often thought that Mr. Carnegie prevented Chicago from being the second largest city in the country, because if the center of the iron and steel business had been changed to the Calumet district as prophetized, the resultant growth of Chicago would have been very large. We might not have occupied second place in size today, as New York in its annexation of Brooklyn made New York a larger city than Chicago could have been, but undoubtedly this city would have been second in size for many years prior to the late New York annexations. But when the United States Steel Corporation, of which the Carnegie Steel Company is the most important element, wished the best location for a new plant, the Calumet district was selected for the Gary works.

The Calumet district has always been of great interest to me, although it is a locality of swamps and shallow lakes, in former years the paradise of the duck hunter and fisherman. As some interesting changes in the flow of the rivers have occurred since the advent of the white man, it has seemed to me that it would be interesting to present maps showing the former condition of the water courses as compared with those of the present.

Map No. 2 has been compiled from information afforded by the records of the Chicago Historical Society, also as furnished by Major Liljencrantz, Mr. Albert F. Scharf, and Mr. Ellis Bennett. Mr. Scharf is an archæologist, who has made extensive studies of the Indian, and it is from his maps that the name of Konomic for the Calumet Rivers was obtained. It would appear that this was a very early English translation of the Indian name, later on called Konom-



Map. No. 1



Map No. 2

ick, and now known as Calumet. As shown on Map No. 1 the Little Calumet River, having its head waters in Indiana, flowed west to the vicinity of what is now Blue Island, where it was joined by a stream now known as Stony Creek. From this point it doubled back upon itself, flowing eastward and parallel thereto, where it found an outlet into Lake Michigan, that portion flowing westward having been called Little, and that portion flowing east having been called Grand from Indian times to the present, notwithstanding that it was all one river. During this time Lake Calumet was drained by a separate and distinct stream, now known as the Calumet. Old French maps show very clearly that there was no connection between the Calumet River and the lakes of Wolf, Hyde and George; the latter group having their own outlet which has in later times been known more or less under the name of Wolf River.

Reference to Map No. 1, shows that there is now a connection between the Grand Calumet and the Calumet River at Hegewisch, and it would appear that the Indians and early French traders probably dragged their canoes overland between the Grand Calumet and the Calumet River, and in so doing established what became during some period of high water, an incipient channel which, once started, grew rapidly by erosion, establishing a new waterway. The water flowing in this new direction instead of through the old bed, resulted in the mouth of the Grand Calumet becoming silted up, reversing the direction of its flow. Thus its grandeur departed. Drainage was then from two directions to Hegewisch and from there to the Calumet River. A military map, prepared in 1812 by General Hull, appears to be the first one to show the existence of this new connection, referred to on his map as a "canal," and shown to be much smaller in width than the rivers which it connected.

Reference to Map No. 1 will show that a new outlet from the Wolf Lake system has been established to the Calumet River. It is not clear when this occurred, but possibly at a more recent period than the other connection just described. The three original outlets to Lake Michigan namely, the Calumet, Wolf and Grand Calumet Rivers, became silted up at various times during the dry season, when the flow was at a minimum, and it is probable that on one of these occasions Hyde Lake broke out to the Calumet River and established a new outlet; thus, instead of this district having three outlets to Lake Michigan, there became only one and that by the way of the Calumet River. It would also appear that after this occurred, these outlets became silted at various times so that there may have been high water in Lake Calumet and also in Little and Grand Calumet Rivers, with the result that Wolf Lake might have broken through again into Lake Michigan, and it would appear as probable that, under conditions of various degrees of silting up of these three outlets, the usual flow of the water was interfered with, so that the course of the old channels was to some extent followed. Mr. Bennett has told me of driving across the Calumet near its mouth with a load

of hay during dry weather between the years of 1865 and 1867. Since the dredging of the Calumet River, the natural direction of the flow has been permanently established, although the ice company which operates in Wolf Lake has opened the channel at "Wolf River" as well as dammed the outlet to Hyde Lake at various times.

It would appear that the first act of improvement of the Calumet River was the construction of a small pier where the north side of the mouth of the river is now located. This intercepted the wash from Lake Michigan, so that the river broke directly through the sand bar. The direction of "Wolf River" was also changed by the building of a pier on each side as shown in Map No. 1, so the present outlet, when not filled with sand, is between these piers.

Recent maps do not show Hyde Lake, as a large portion of its area has practically disappeared. The maps of the United States Geological Survey, from which these two of mine have largely been copied, show the Wolf Lake outlet as extending directly south, then turning north, from which point it reaches westward to the Calumet. The channel, however, has always been straight across Hyde Lake from Wolf and westward. It appears that, when certain railroad tracks were built in this locality, a dredge was taken down the Calumet, from which point it cut a new channel part way to Hyde Lake, the remainder of the distance using the original one, and railroad embankments were raised by dredging material from a long ditch on the eastern border of the lake. This excavation extended to the southernmost point of the lake from which another embankment was made by dredging in a northwesterly direction, although, as shown on the map, this channel has been closed by a fill, which furnishes a road to what is practically an island in the lower end of the lake. While there is a small culvert in this fill, the real outlet is straight west from Wolf Lake, across Hyde, as shown.

While a large portion of this Calumet territory is in Indiana, and some of our most important recent industrial harbor development is in that state, the whole thing is so connected that, as an industrial harbor proposition, it cannot be separated.

Isham Randolph, M.W.S.E. (by letter): As a preface to my discussion of the report of the Harbor Commission, I will say that said report presents a compromise of the individual views of the members of that Commission. No one of the eight men who composed that Commission would have presented that report as the embodiment of his own conclusions; hence it represents concessions in the interest of harmony and getting somewhere.

For my own part, it required no little repression of self to refrain from sending in a minority report, which I actually prepared.

The men on that Commission gave the task submitted to them their best thought and patriotic honest labor, and their differences were not captious. We differed, differed honestly, and were absolutely frank and above board with each other.

I came to the task, perhaps, with more of preparation than any

other member of the Commission, for my study of the subject began seventeen years before this Commission was appointed, and my work for long years had been on lines which tended to equip me with ideas that were ready to be moulded into conclusions of more or less worth.

I was, and am, radically in favor of a harbor on the Lake Front between Sixteenth Street and Forty-first Street. The greater part of the paper which I shall now present will be excerpts from papers which I have written upon this subject at sundry times, and my minority report will be quoted from at considerable length.

In 1891-2 I was a member of a Commission appointed by this Society to report upon R. R. and Harbor terminal facilities for this city. When the report of that Commission was presented to the Society, I submitted a minority report on the harbor question. The march of events has greatly changed conditions, but some of the conclusions I then reached are valid to-day. I then stood for a Lake Front Harbor and I quote:

"The communication of this harbor with the interior must be considered. No railway should be allowed to enter this new domain at grade, but an adequate system of tracks should be provided under restrictions which would forever prevent their becoming a monopoly controlled by any connecting line. Every railroad entering Chicago should have the right to use the tracks upon terms of equality with all competitors."

Again I quote:

"When the esthetic side of this question is presented, it is elbowed by the very prosaic fact that no city can thrive upon the beautiful alone, and the prosperity of Chicago can never be sacrificed to gratify the tastes of the few who have wealth and leisure to bestow upon such enjoyments as lovely drives and pleasing landscapes, with wide expanse of waters for a background."

1892 is a long way behind us, and I shall not quote again from that report, but will incorporate in my present discussion what I have written in the very recent past, first using a part of a paper which I prepared for the *Record-Herald's* Waterway issue of August 29th, last. And the basis of that harbor discussion was the minority report which I refrained from presenting.

For reasons which a consideration of the city's geological location, coupled with its distribution of population, will make clear, such a commerce as Chicago ought to have cannot be accommodated in the Chicago River.

This is a triune city, its smallest division, the North Side, has a population greater than Milwaukee. Its next smallest division, the South Side, has a population greater than Buffalo and Detroit combined. Its largest division, the West Side, has a population greater than Buffalo, Cleveland, and Duluth combined, and the aggregate population of the three divisions exceeds the combined populations

of Buffalo, Cleveland, Toledo, Detroit, Milwaukee and Duluth. These six cities, however, outstrip Chicago in the aggregate volume of their water-borne commerce.

These divisions of our city are not civil or imaginary; they are natural, and the Chicago River and its branches—North and South—separate these parts of a mighty whole.

The more than 350,000 inhabitants of the North Side wish to do business with the more than 750,000 people on the South Side, and the 1,000,000 or more people of the West Side are eager to do business with their neighbors across the stream, which eagerness is reciprocated by the people of each of the other divisions.

For these millions of people to mingle in the ways of trade and in social and political intercourse they must use the five (5) bridges on the main river, the fourteen (14) bridges on the North Branch, and the twenty-two (22) bridges on the South Branch.

These human tides do not ebb and flow twice in twenty-four hours, but they meet, mingle, and move in opposite directions, in all of the hours from dawn until midnight, and interruptions due to opened bridges for the accommodation of river traffic are met with maledictions loud and deep.

Manifestly, such a lake commerce as Chicago ought to have cannot be carried on in its river without imposing a real hardship upon the hundreds of thousands of people who must, in the legitimate pursuit of business or pleasure, cross and recross these bridges at all hours of the day and night.

What, then, does Chicago need in the way of a harbor?

My answer to this question is: It needs a harbor of such depth that the heaviest laden modern freighter can float in it; a harbor so arranged that vessels can enter and depart under their own steam without the assistance of tugs; a harbor ample in area to serve as the anchorage for any fleet likely to seek its shelter; a harbor amply protected by breakwater or sea wall; and—most vital to its success—a harbor so located that every railroad entering the city can reach it; and that, too, upon terms of equal advantage to every user.

The docks of this harbor must be equipped with every convenience for handling the freight and making transfers from hold to warehouse, from warehouse to hold, and for interchange between rail and water-borne commodities.

There must be room, abundant room; room for tracks, warehouses, elevators, passenger accommodations, and all of the industries that enter into the life of a great port.

This should be the place from which through shipments move to destination without cumbering city tracks and highways; the place from which local freights may be handled by lighter to and from the city warehouses and depots along the river; the place where bulk shall be broken in the interchange between the users of the "Lakes-to-the-Gulf" waterway and the lake carriers.

Where in or near Chicago can the ideal site for such a harbor be found?

This location is very apparent. It lies like a fallow field waiting to be put to the highest use to which in the service of the city it can be dedicated; it stretches along the waterfront from Sixteenth Street to Forty-first Street. Nowhere else is there an area so accessible to rail and water. Nowhere else can the commerce of Chicago be so located as to bring rail and water into such complete and ample contact. Nowhere else can such harbor facilities as Chicago ought to provide be created for so small an expenditure.

The Lake Front has been monopolized by one railroad south of the main Chicago River and north of that river access has been had to it over one other railroad only. These two have controlled any Lake Front harbor development. They have been able to dictate the terms upon which any other road should do business with lake shipping. That such a condition is calculated to strangle interchange between lake and rail is apparent. With these convictions prompting my studies, I have sought to find the line of least resistance to any comprehensive plan for bringing all of the railroads to the lake, and to select the locality which would lend itself most fully to the development of a harbor worthy of Chicago's future, and adequate to her needs, if not for all time, at least for many generations.

My active participation for twenty-eight years in the railroad and waterway construction in and around Chicago has given me a comprehension of the local conditions upon which to base my convictions. My first care has been to select a route which would form a connecting thoroughfare for all of the railroads and lead them along an ample right of way to the Lake Front somewhere. Naturally enough, my thoughts in this connection turned to the Illinois and Michigan Canal as an available entrance to the city.

This canal was once a force for good in the upbuilding of Chicago, before the march of progress dwarfed its capabilities and it was outstripped by the railways. When no longer a highway of commerce because it had been outgrown, it entered upon another career of usefulness as the outlet for a vast amount of Chicago's vilest sewage, which was lifted into it by the city sewage pumps at Bridgeport, and just to the extent of that pumping was the water supply preserved from pollution. But that was an alleviation only, and not a cure, and so the Sanitary Canal was built, and thereafter the old canal from Chicago to Joliet lost its claim to usefulness. But another career is open to it. The cost of railroad terminals in our great cities has become so great that it is a check upon railroad building, and cities suffer the loss of multiplied means of communication because their gates are shut against new comers in the family of railroads.

The destiny of the Illinois & Michigan Canal should make it the highway along which new railways may enter Chicago upon living terms, and over which existing railways may interchange business economically. The right of way of this canal is 240 feet wide (28.80 acres to the mile), and four and one-third miles of it are within the

city limits. This stretch at least should belong to the City of Chicago. The property right in it should be secured from the general government, and the state should vest its right thereto in the city. This is equity. The canal was built for commerce, commerce has deserted it, and by its side flows a channel which in depth and width meets the needs of the great inland freight carriers of our modern times. This new channel has been provided by Chicago free of any expense to government of nation or state, and whatever salvage there may be in the old canal should be given to the people who have paid for the new. This canal right of way is crossed by belt lines and trunk lines; it is paralleled by trunk lines. The lines which cross it are so high above its surface that a 17 foot head room can be secured. This right of way will accommodate 18 lines of track laid 13 feet apart center to center. It terminates at the West Fork of the South Branch. This canal right of way can be connected with the Lake Front harbor over a route which traverses property which is to-day of little value and sparsely settled. This route would extend from the canal right of way southeasterly to a junction with the Stock Yards tracks, which cross the city on the line of 40th Street. It could parallel those tracks on a contiguous right of way as far as the Lake Front. This location avoids a new invasion of residential property and creates no added nuisance in crossing the city. It could enter a harbor reservation at or above 40th Street. Between that street and 16th Street a harbor can be developed ample for all of the present and future needs of Chicago. No other location is so conveniently located to meet all of the needs of the city. Nowhere else can lands ample in extent be so cheaply acquired for the uses of a lake and rail terminal. Nowhere can rail and water meet to serve Chicago and build up her wealth and prosperity as in the stretch indicated. This location avoids augmenting the congestion of the sorely overtaxed business center of the city, and yet it is so situated as to be easy of access to the industries of the city which are dependent upon public carriers for their intercourse with their customers and the supply of the materials used in the conduct of their business. Nowhere else can provision be made for street car and elevated road communication with the harbor area with such slight extension of the existing and nearly adjacent public utilities. Here every class of water-borne commerce can be accommodated with ease and admirable convenience.

The plan outlined would bring into the harbor area over the southern right of way, the following railways: The Santa Fe; The Illinois Central, (Sioux City Line); The Wisconsin Central; The Chicago and Alton; Belt Railway of Chicago; The Illinois Northern; The Illinois Western; The Pan Handle; The Chicago Terminal Transfer; The B. & O.; The Wabash; The Grand Trunk; The Erie; The Monon; The Chicago & Western Indiana; The Pennsylvania; The Chicago, Rock Island & Pacific; The Chicago & Eastern Illinois; The Lake Shore & Michigan Southern; The Chicago, Milwaukee & St. Paul (over the Stock Yards tracks); The Chicago and Great

Western (over the Chicago Terminal tracks). The Illinois Central, the Michigan Central, and the Big Four are now on the Lake Front adjacent to the proposed development. The Chicago & Northwestern and the C. B. & Q. being part owners with the Illinois Central and the Lake Shore & Michigan Southern in the St. Charles Air Line, they would have access to the proposed harbor area from the north end. Such an aggregation of roads would need a large area for tracks to serve the harbor, and nowhere else can the necessary area be procured or created adjacent to navigable water for so small an outlay of money and labor. A description of the details of construction of such a harbor as is here presented in a broad way, would be out of place at this time, so it is omitted. Nowhere else can such conveniences be provided at so small a cost for the traveling public and the business public who would want to reach this harbor area. A short loop track from the Alley Elevated along, say, 18th Street would give access to its patrons and those from connecting lines. The Indiana Avenue line could be brought in on 18th Street and carried along the whole water front with cross connections to Cottage Grove Avenue. Into this area the existing underground railway—miniature of what Chicago ought to have—could be brought,—brought, however, with due care that it shall not block the coming of the real subway, which Chicago's necessities will bring into being at no distant day. An avenue not less than 200 feet wide should be reserved along and contiguous to the east side of the Illinois right of way. Or, better still, the right of way of the Illinois Central should be shoved east 200 feet and its present right of way be used as an avenue or boulevard. The government should protect this harbor with an ample breakwater. For the rest, the city must work out its accomplishment in ways to be devised by business statesmanship. The first step which I urge is a vigorous effort to repeal the legislative enactment which gave the South Park for beauty what the city needs for business. Give back to commerce and industry all of the Lake Front from 16th to 41st Street and let the parks have all of the rest. Is three miles out of twenty-two miles of water front too much to ask for Chicago's commerce? Then condemn all riparian rights on the reclaimed stretch. This vast improvement should be undertaken and carried out not as a revenue bearing project *per se*, but to build up the commerce of the city. Manchester (England) put seventy-seven million dollars into its ship canal, that it might become a seaport. The traffic on that canal has not earned a return in tolls which would justify its construction, but its building gave Manchester an impetus in growth, and the wealth attendant upon growth, so vast that the millions put into the canal are insignificant contrasted with the results.

On pages 33-4 of the report of the Commission there is a dissertation on the evil effects of the current in the Chicago River, and the need for slowing it down, and a note following this dissertation records my dissent.

Now, I have yet to hear a complaint based upon the velocity of the current in those stretches of the river in which has been obtained the depth and cross section called for by the plans of the Sanitary District of Chicago. The current throughout the South Branch, when the whole work is completed, will fall below the government requirement limiting the velocity to $1\frac{1}{4}$ mile per hour. There will be a slight acceleration of current in the bridge openings.

My associates on the Commission looked favorably upon a suggestion that the velocity in the stream be reduced by introducing at or near 16th Street a volume of water from the lake through a conduit. I called attention to the fact that such introduction would so diminish the slope in the stream as to vitiate the plans of the Sanitary District. There must be a steady inflow from the lake through the main Chicago River, and the hydraulic gradient south of the forks of the river must be sufficient to maintain that flow, otherwise the polluted waters effluent from the North Branch would escape into the lake via the main river. The distance from the lake via the main river and the south branch is nearly $3\frac{1}{4}$ miles, while the distance from the lake to the east bank of the river via 16th Street is only 3,900 feet; so it is readily seen that the introduction of water from the lake at or near 16th Street in any volume which would diminish the hydraulic gradient north of that point would be disastrous to the sanitary project.

BRIDGE OPENINGS.

The first two bridges built by the Sanitary District across the Chicago River, provided for the Taylor Street crossing and for the Chicago Terminal Transfer R. R., and their clear spans between pile protections simply met the Federal requirement of 120 feet at right angles to the thread of the stream; after that, nine other bridges were built by the district with 140 foot openings between pile protections measured at right angles to the thread of the stream. In these later bridges Federal requirement was exceeded by 20 feet. This provision, in my judgment, meets every reasonable commercial demand.

It is truly urged that no two of the great freighters could pass each other in an opening of only 140 feet; they cannot, and they do not need to. I quote from my reply to an attack made upon me for my measure of responsibility for these 140 foot bridges:

"If these freighters were not barred from other causes the bridges would not keep them out of the Chicago River. A proper system of handling such traffic would designate passing points. Vessels should be despatched just as they are in the Suez Canal. There, no two large vessels are allowed to pass each other both being in motion; in that canal one must lay by until the other passes, and they move under orders from the canal despatcher. Vessels of the large class can pass between Clark Street and Fifth Avenue; between Madison Street and Adams Street; between Harrison and Polk Streets; between Polk and Taylor Streets, and in any inter-bridge section of the

river south of 12th Street, except between the Fort Wayne Bridge and Canal Street. The Chicago Harbor Master can direct the movement and designate the passing places for boats.”

As a concession to public opinion, I would be willing to require that all future bridge openings be 200 feet in the clear, provided the cost of so doing, including damages to abutting property, would not be more than 20% greater than the cost of the 140 foot openings. We are assured by owners of patented designs that this increase in cost will not be exceeded if their designs are used. This may be so but, like the Scotchman, I “hae ma doots.” The desirability of level bottom chords for all these river bridges cannot be questioned.

There is a constant harking back to the project for a channel from the lake to the river somewhere south of 16th Street. In a written discussion of this project which I submitted to my associates of the Harbor Commission, I said:

“ It has been suggested that a new channel be constructed across the Northern peninsula of the South Side, and that north of this new entrance the bridges across the South Branch be made fixed structures. An admirable suggestion this, and one which I worked on and abandoned all hope of about ten years ago. Some of the obstacles to this project are readily admitted. Corporate interests are almost impregnably intrenched in their vested rights. Foremost in the ranks of opposition are the Railroads. Starting from the Lake Front, we first meet the Illinois Central R’y with its 200 ft. right of way, and its network of tracks. Next in order is the South Side Elevated Road. Then the Lake Shore & Michigan Southern and the Chicago, Rock Island & Pacific Railways. Passing these we come to the Penna Co., closely paralleled by the Chicago & Western Indiana R’y and its tenants, the Grand Trunk, the Wabash, the Monon, the Erie. Then the Alton, Santa Fe and Illinois Central group must be crossed. Thus it will be seen that a most formidable aggregation of public corporations would make common cause against a new channel across the South Side. The location for such a channel which I have in mind in this discussion is South of 22nd Street; a location North of this would be complicated by the existence of extensive railroad yards.

“But the opposition of these public corporations would be insignificant compared with the opposition of the people of the South Side. The business heart of the city exists in the northern end of the South Side peninsula. The South Side is in direct and unobstructed communication with this business center, and it has a vast advantage by reason of this fact. An advantage which they would not yield without a struggle akin to that which they would make for the right to exist.

“As before said, the business center is at the Northern end of the South Side. For some subtle reason, this location has attracted to itself the concentration of Chicago’s business devel-

opment. Here are its great stores ; here are intrenched its banking interests ; here its great office buildings ; here the seat of civic government ; here its art treasures ; and here centers the Federal power in this State. All these by natural selection have identified themselves with the South Side, and from these the South Side will not be divorced by any artificial creation. More than six hundred thousand people, aroused and contending for their birth right, cannot be satisfied by our theories of what ought to be. The channel to the West has entered by Nature's route, not the best one by any means, but there it has the right of way. Every other suggested route has a barrier across it and the point of least resistance remains to be found."

Pages 55 to 58 of the Report of the Commission give its recommendations in concise form. Of most of these recommendations my approval is hearty, in some I merely acquiesce, and with one or two I disagree.

Taking the Chicago River (Main and South Branch), I am in hearty accord with (a) and (b). (c) I consider a concession to public clamor, which should be made if the cost does not exceed the cost of 140 foot clear spans by an amount greater than 20%. (d), (e) and (f) I am in accord with. (f) I favor not so much for its effect on navigation, as I do on the ground that it will widen the space between Clark Street and the River, and provide area for the South Side Union Depot, which we ought to have. (g) has my hearty approval. Against (h) I protest for reasons given in my previous discussion. (i) seems to me to be a commercial necessity.

When we come to "Chicago River (North Branch)," I am in perfect accord with everything until (h) is reached, and I have no quarrel with anybody who wants to make the investigations there suggested. My own study of the question satisfies me that the North Shore channel will never be a navigable waterway for craft other than lighters, barges, and tugs which require 16 feet of head room or less.

We now come to "Lake Front." There I swallow the first four letters of the alphabet, but (d) sticks a little. I regard the harbor south of 16th Street as being of paramount importance. If the park feature can be made to work into the scheme without detriment to the harbor, well and good, but the importance of the harbor overrides every consideration or dream of beauty.

"Illinois & Michigan Canal"—I am enthusiastically in favor of that proposition.

"Calumet River & Harbor"—Those recommendations are all right. Chicago's growth will demand the facilities suggested there as well as the Lake Front harbor, but I put the Lake Front harbor before the Lake Calumet development.

"Harbor Administration and Finances"—All that is there recommended is most desirable.

CLOSURE.

Mr. Ewen: It seems to me that Mr. Sherman does not give sufficient thought to the necessity of providing for package freight, fruit and vegetables consumed by Chicago proper. This freight cannot go to Calumet and be hauled to the consumer who is in the neighborhood of the Chicago River, its branches, and the West and North West Sides. Neither does he give any attention to the passenger business, which is of great importance and should be encouraged. What he says about Calumet is true. The industrial harbor once started there will soon develop the territory in the Calumet region, so that it will have the requirements for supplying its population as that section grows in the near future. Its industrial harbor will also become a commercial harbor, with all the facilities for supplying food and clothing, fuel, and all requirements to its people at minimum cost. It is hoped that this will be done and that Calumet will not find itself in the position Chicago proper finds herself, with most inadequate facilities for handling marine commerce.

I have read with much interest all that Mr. Dart says, and can state that all of the difficulties he recites were brought out in the Harbor Commission work. There are many difficulties that will require the best work of the best engineers to solve. What we want to do is to get the city of Chicago to start the work, and to get as quickly as possible an organization that can properly cope with these difficulties and solve them. For solve them we can and will.

Referring to Mr. Bement's discussion, I have the same faith in the Calumet district that he has, but in order to accomplish anything there a policy must first be established by the City Council of Chicago that will embrace the whole territory, including the Chicago River, outer harbor, and Calumet. This is what we are trying to do now, and the work of the committee from this Society, cooperating with the Council Committee and the Harbor Commission will, in my opinion, bring about the results quicker than in any other way. The finer details can be worked out after proper organization. I look forward to this winter's work as accomplishing much for Chicago in getting started on a plan embracing all this territory in a broad sense.

MINE ACCIDENT INVESTIGATIONS OF THE UNITED STATES
GEOLOGICAL SURVEY.

GEORGE S. RICE, M.W.S.E.

Read December 1, 1909.

The coal fields of the United States are of tremendous extent, and besides indicating the great resources of our country, show the difficulties of the Mine-Accident Section of the U. S. Geological Survey in attempting to cover the wide-spread areas. There is the great Appalachian Basin, running about 1,500 miles northeast and southwest; the Eastern Interior field, which embraces Illinois, Indiana and western Kentucky; the Western Interior field, running from Iowa down into Oklahoma; and then the great Rocky Mountain fields, where the coal runs practically through from outcrop to outcrop, although at great depth, and for that reason it has not been figured into the resources. Finally, we have the limited but valuable Puget Sound fields.

The work that I am to describe is that connected with mine accidents, and the scope is limited only by the great fields mentioned.

In 1908, as a result of the great series of mine disasters during 1907, in which 1,148 men were killed by explosions, 648 in the single month of December, Congress made an appropriation for the investigation of coal mine accidents, and placed the work under the Technologic Branch of the U. S. Geological Survey.

This appropriation became available on July 1, 1908. A number of mining engineers and chemists were at once engaged to form a mine accident division and the reconstruction of old buildings on the Arsenal grounds at Pittsburgh, Pa., for a testing station, was immediately begun. This work was finished and machinery installed before winter. The formal opening took place on December 3, 1908. Fuel testing and structural material investigations are also carried on at the same station, but we are concerned in the present paper only with the Mine Accident Investigation. Dr. J. A. Holmes, Chief Expert, is in charge of the Technologic Branch, with headquarters at Washington.

Mr. H. M. Wilson, also of Washington, is Chief Engineer and Mr. J. C. Roberts, Assistant Chief Engineer, has immediate supervision of the Pittsburgh Station.

By far the larger number of men engaged in mining killed in mine accidents are victims of falls of roof and coal. From all causes the number thus killed and injured reaches enormous proportions. 2,092 killed and 4,800 injured in 1906; 3,125 killed and 5,316 injured in 1907; and 2,450 killed and 6,772 injured in 1908.

Diagram A shows the number killed per 1,000 employed each year since 1890. Most unfortunately the number has shown an increase instead of a decrease, whereas abroad the opposite is the case. In the number killed per 1,000 employed we are now where

Belgium was eighty years ago. Everyone of the foreign countries has shown a marked decrease in the number of mine accidents. The present contrast is very marked, as shown by the following table from U. S. Geological Survey Bulletin No. 333.



DIAGRAM A
NUMBER OF MEN KILLED IN COAL MINE ACCIDENTS
EACH YEAR FROM 1895-1908 PER 1000 MEN EMPLOYED

Number of men killed for each 1,000 employed—average for five years:

France	(1901-1905)	0.91
Belgium	(1902-1906)	1.00
Great Britain	(1902-1906)	1.28
Prussia	(1900-1904)	2.06
United States	(1902-1906)	3.39

I am sorry to say we head the roll in the number killed. In this table we take account only of those killed, because it is much more difficult to account properly for the number of injured, but that is usually about twice the number that have been killed. Ours is a sad contrast with these foreign records. We may well ask what is the reason. Our mechanical equipment has improved, yet the statistics show a slightly increasing rate in the loss of life, while in all other civilized countries there is a decrease.

The writer's study of conditions abroad leads him to believe that the important factors are—lack of discipline and lack of knowledge, the use of long flame explosives and in construction, the use of inflammable material in shafts and shaft bottoms. The burden is usually laid upon carelessness on the part of the individual miner. After all, that means lack of discipline. One careless man can endanger the lives of four or five hundred in a large mine. Whether

the non-enforcement of discipline is due to the labor unions or to the lack of unity on the part of the operators, or the non-enforcement of laws on the part of the state officials, is too complicated to discuss in this paper.

Ignorant men are found in all countries. It is well known that experienced miners, trained abroad, when they come to this country disregard all matters of safety that have been enforced in the older countries.

I remember an instance in a gassy mine in Pennsylvania, I saw an English miner of intelligence place his lamp on the floor—on an irregular floor. I said, "What would happen if you did that in Yorkshire?" "Oh," he said, "I would be fined." That would be because it might fall over and the flame crack the lamp glass. If the latter was broken from any cause it would mean a heavy fine or imprisonment, if gross carelessness were shown. The finding of matches or even tobacco, in the clothes of a miner means a fine at least. The annual reports of the English inspectors show pages of such convictions and punishments.

Until we obtain better discipline the writer does not hope to see a very material improvement in the conditions here. Methods can be adopted by the individual operators to lessen the risk of great explosions or disasters, but improvement at the face of the mine can only be effected by discipline and unceasing vigilance. These matters are in the hands of the mining public and the state officials. The Geological Survey can only hope to carry on a campaign of education. But in the lessening or prevention of great disasters, while less prolific in loss of life, cause the greatest horror, the Survey can furnish direct and valuable assistance.

It is safe to say that three-fourths of the great disasters that have occurred in this country, have been due to the use of dynamite or black powder, chiefly the latter. The greater part of the coal fields are not troubled with a serious amount of methane, which when mixed with air becomes fire-damp, or what is ordinarily termed simply "gas." In general we have nothing like the amount of gas as found in the deep mines of England and the continental countries, particularly Belgium, where there is an astonishingly small loss of life.

We have very few mines which must use safety lamps exclusively, whereas in Belgium they use nothing else and the flow of gas in the mines is frequently very strong. The writer visited a mine at Frameries in which a very historic incident had once occurred; an outburst of gas which reversed the ventilating current in the down-cast shaft and took fire, not down in the mine but at the surface, and burned for a considerable period; naturally, the men were killed. A few days before the visit of the writer to this mine, at a neighboring mine there had been an outburst of gas so strong that it suffocated three men, yet their lamps and discipline were such that there was no general explosion; the men killed were simply

smothered. Great depth is reached by the Belgian mines. One that the writer visited went down to 1,050 meter level, which would be a little over 3,300 ft. deep. It was noticed that at this level cowbells were hung from chains strung across the gangway near the escape shaft. These were so placed that in case of an outburst of gas, which might put out the safety lamps, the miners would hear the cowbells and be able to get back to the escape shaft.

In this country fire-damp is not our chief menace, but fires and coal dust are, as they constitute our dangers in bringing on large disasters, the larger loss of life coming from the latter. Very little attention has been paid to the danger of coal-dust until within the past few years, though some scientists and mining engineers have recognized its danger for many years. In fact, as early as 1803 the suggestion was made after an explosion in England that coal-dust might have been a factor. However, widespread attention among mining men was not attracted until the report of the British Royal Commission in 1894. Various continental countries had taken up the study of the explosiveness of coal dust and a number of galleries were erected for testing the same in the presence of gas and alone. As the result of the experiments, the important coal producing countries prohibited the use of black powder, or other long flaming explosives.

Then followed the invention and introduction of so-called safety explosives, which while not entirely free from flame are so nearly so, that under proper restrictions they will not ignite fire-damp or coal-dust. Certain countries, like Belgium and England required explosives to be submitted to a series of tests in the presence of gas and dust, and only those which passed were placed on the "permitted" lists. France, Austria and Germany have rigid requirements, differing in details. In England black powder is still permitted in non-gaseous and non-dusty mines, but the other continental countries allow no exception.

On the establishment of the Pittsburg Station, it was felt that the most important immediate work was to test mine explosives and this has been the chief work of the Mine Accident Division of the Station during the past year. The director of the survey, Dr. George Otis Smith, sent letters to all explosive manufacturers, inviting them to send explosives to the station for testing under certain conditions. Those that pass are placed on what is termed a "permissible" list. Up to date over 30 explosives have passed the rigid requirements. Mr. Clarence Hall, explosive expert, has conducted this work, assisted by the chemist, Dr. W. O. Snelling.

The Government has no authority to enforce the use of these explosives, but the State Mine Department of a number of states have been endeavoring to secure the adoption of such explosives in the place of black powder, dynamite and other long flame explosives. Special progress has been made in Pennsylvania and West Virginia, where the State Inspectors have demanded their use. Complete en-

forcement has not yet been secured but most of the leading companies have adopted the explosives. As yet we have no authoritative figures as to the extent of their use, but from observation of the writer and the other mining engineers, it would appear that nearly one-half of the coal produced in Pennsylvania and West Virginia is being shot down with such explosives. They are also used extensively in Oklahoma. In Indiana and Illinois as yet, very little progress has been made in their introduction, although they are being used in a few mines in southern Illinois in driving entries in more or less gassy coal.

As a whole, the progress has been so rapid since the issuance of the first list of "permissible" explosives, in May last, that it does not seem improbable that in a few years more the use of black powder will be exceptional, and thus, one of the greatest causes of disaster, particularly that have occurred in Illinois, will be partially, if not wholly removed.

Among other work of the Survey at the Pittsburg Station, tests of safety lamps and of mine rescue apparatus are being carried on under the immediate direction of Mr. J. W. Paul. Mr. H. H. Clark, electrical engineer, has begun a series of tests on electric conductors, switches and machines used in mines with a view of lessening the dangers from these sources. It is not alone the question of killing or injuring the men by electric shocks, but there is a real danger from causing fires or in gassy mines in igniting the gas.

The field mine accident investigations of the mining engineers are under the immediate charge of the writer. Owing to the limits of the appropriation the mining engineers are few in number, considering the immensity of our coal fields. The general plan is to establish stations at the important mining centers, from which the mining engineers will go out for the investigation of mining conditions in the respective district. A few have already been established. The mining engineers make examination of everything relating to the safety of the individual mine, as the hoisting and haulage equipment, the fan and the methods of escape. Observations are made of the ventilating currents, the humidity of the same and samples are taken of the mine air and gases for analysis. The quantity of coal dust, its distribution and condition are noted, and in some cases samples are taken.

In connection with the conservation of coal and the study of fuels, the mining engineers take samples of coal at the face and observe the roof and floor and make notation as to the method of mining and the amount of wastage, both below and above ground.

When a mine accident happens, one or more proceed as quickly as possible to the scene to render such assistance as they can give. When the mine is near enough to the existing station, rescue apparatus is taken. While our mining engineers were not originally engaged to undertake rescue work themselves, they have not hesitated to volunteer. During the past year, after every explosion of any size,

the mining engineers have proceeded as quickly as possible, taking the rescue apparatus with them. In many cases they could not arrive in time to render assistance.

Primarily it is not the purpose of the Survey to undertake the maintenance of a life saving corp, but the object is to try to educate the operators and miners to the advantages of the rescue and fire fighting apparatus, so they may be interested to establish joint-rescue stations in each important mining center. Such joint-rescue stations have been extensively introduced in foreign countries and in Germany, Belgium and France rescue apparatus and the training of a certain proportion of men employed is now required. To get the best efficiency from the rescue apparatus, practical miners should be trained in their use, and thus having a trained corps of men who know the individual mines in their territory and who are accustomed by constant training to the use of the helmets. Far more can be accomplished with such a station than is possible by a remote government station, whose operators are professional men, occupied in scientific work and not having the physical strength and **endurance** of the men who should constitute such corps, nor have they knowledge of the mine to be entered—a most important matter, particularly where the underground mine officials have been lost in the disaster. In saving life, or fighting fire, the difference is like that between trained firemen and the volunteer.

Nevertheless, our mining engineers have been able to accomplish a great deal, by direct work themselves and by training men on the ground, to the use of the apparatus. Notably in the Marianna disaster, the rescue apparatus was brought quickly to the scene and a new method of recovering a mine after an explosion was adopted. Instead of at once turning in ventilation, men went down in helmets, incidentally rescuing the only survivor, and put out smouldering fires in the immediate vicinity of the shaft before the ventilation was restored. Before each section of the mine was ventilated an inspection was made with the helmets to insure that the fires were out. Thus one very great danger of reopening a gassy mine was avoided. For if ventilation had been turned into the entries with fires burning, successive explosions would have resulted, with a possible loss of the mine and the non-recovery of the bodies, as happened last spring in the West Frankfort mine.

Our mining engineers have been successful in putting out a number of dangerous mine fires in Pennsylvania, using the helmets, and having to seal and unseal fires in Pennsylvania, Ohio, West Virginia, Indiana and Illinois.

After the recovery of the mine, the mining engineers have been called upon to make careful investigation of the causes and course of the explosion. This work has occupied a very considerable part of the engineers' time, as they have visited the scenes of explosions in half a dozen states, in fact every explosion of any size in which a number of men have been lost. These reports cannot be made pub-

lic, although we are able to informally advise the operators if conditions are such that there is liable to be a repetition. But it is not possible to make such reports public, inasmuch as this is a function of the State Mining Departments.

Supplementing the field work of the mining engineers special studies have been made at the Pittsburgh Station of the explosibility of different coal dusts and a special series of tests were conducted under the direction of the writer, with a view to finding remedies for this danger.

While the greatest source of danger comes from long-flaming explosives, even when the "permissible" explosives were used, there are other causes of ignition to be eliminated. A small explosion of fire-damp may readily cause a wide-spread dust explosion. It has been claimed that the breaking of a trip of cars in a Wyoming mine caused a concussion and ignition of coal dust.

The results of these studies and tests is about to appear in a bulletin to be issued by the Survey and entitled "Preliminary Report on the Coal Dust Problem—Suggested Remedies."

While a considerable number of remedies have been proposed the easiest is to thoroughly wet the coal dust by the use of hose, continuously running sprinklers, or artificially humidifying the intake air by steam.

It may here be stated that this does not mean any partial wetting of the dust. The writer was very much surprised at the results of the special tests, in the explosion gallery, with coal-dust, dry and wetted. Briefly, it was found that much coarser dust than previously suspected took part in an initial explosion. There was practically complete propagation with dust through 20 and over 40 mesh screens, so that coal through 20 mesh was considered dust. How much of a part still coarser dust may play when a big explosion is once under way, we cannot tell. We are particularly concerned in preventing the start of the explosion.

The other tests of great interest concern the amount of wetting required to make coal-dust inert, when there is a blownout shot. Using $2\frac{1}{2}$ lbs. of black powder, in such a shot, we found that the coal-dust would explode when it had up to 20% of water with it. It was not till we got over 25% of water that we prevented propagation of the explosion. Coal dust will hold an astonishing amount of water; some dust will hold as much as 35%, before it turns into mud. With 25% you can press it in your hand; it will ball up, but it is not what would be called mud; water is not squeezed out. That points to the necessity of thoroughly wetting the dust to make safe conditions; casual sprinkling or humidifying is not sufficient. Close observations should be made and samples of dust taken and analyzed to determine if conditions are safe.

The Mining Engineers will endeavor to obtain the adoption of one or the other of the several devices and make close observation of the results.

If in future sufficient funds become available, it is proposed to increase the number of sub-stations. Besides the Pittsburgh Station, at present there is a sub-station at Urbana, Illinois, in charge of Mr. R. Y. Williams, to serve this and adjoining states. Another has just been established at Knoxville, Tenn., to serve the southeastern fields, a third has been partially established at Seattle to serve the Puget Sound field. A fourth is about to be started at McAlester, Okla., the center of an important and somewhat dangerous district. As soon as funds are available it is intended to establish a station in the New Mexico-Colorado field, and possibly another in the Utah-Wyoming field.

It is also intended to obtain a mine for experimental purposes, where the various explosives and devices for rendering coal dust inert can be fully tried out, but this must wait until we have the necessary appropriation. Meantime, laboratory experiments will be carried on at the Pittsburgh Station with coal dust, with mine gases, and the writer hopes to have some special tests made of the combustion of coal in a closed space and methods of putting out flame by various chemicals and other means, with a view to application under mining conditions.

We do not really know very much about the subject. There seems to have been very little work done, either in this country or abroad, on the very important matter of mine fires. - We are still using the same crude methods that were used fifty years ago. There is always an uncertainty when we seal up a fire, in a gassy mine at least, whether we are going to have an explosion or not. It is most important that such work be placed on a more scientific basis.



Fig. 1. Dust and Gas Gallery No. 1—100 ft. Long.

In Fig. 1, is shown the explosion gallery, where we test explosives and incidentally show the explosibility of coal-dust without the presence of gas. It is arranged so that gas can be piped to any one of the 15 different sections. The tube is about 6 ft. 4 in. in diameter, and there are windows of heavy plate glass in the middle of each section, so that the progress of the flame can be observed. On the top of the gallery there are safety valves or doors. These would not be needed in that length of tube for coal-dust, for a coal-dust explosion takes time to generate force, but in an explosion of a fire-damp, which is very quick-acting, it is necessary to relieve the pressure. In a concrete block at the end is set a cannon, in which explosives for testing are placed. The cannon has a drill-hole which is 20 in. deep and $2\frac{1}{2}$ in. in diameter, and causes a blown-out shot such as may take place at the face of a working place in a mine.



Fig. 2. Explosion of Coal Dust. Instantaneous Picture of Beginning and Before Explosion Has Reached Middle of Gallery.

Every Saturday last winter we had large numbers of visitors representing different companies whose men came from Pennsylvania, West Virginia, and Alabama to witness informal experiments with coal-dust and gas. Coal-dust is placed on shelves along the side of the gallery and on a wood horse or bracket, which is underneath the line of the hole. This is similar to a condition that frequently occurs in a mine where there is a pile of machine cuttings or coal from previous shots and another is fired over or into it. Under such conditions in the gallery, bituminous dust invariably explodes. The only exceptions we have had to explosions have been in testing anthracite dust from Eastern Pennsylvania. We are not positively sure that under all conditions, anthracite dust will not explode, but probably it will not. They have never had the wide-sweeping explosions

in the hard coal districts that have too frequently occurred in the bituminous fields, although they have had heavy explosions of gas, but these have been of a local character, relative to the others.

The appearance at the start of a dust explosion in the gallery is shown in Fig. 2. That is to say, the photograph being taken instantaneously, it shows explosion at the initiation only, a black cloud and flames issuing from the first escape valves. Such an explosion runs the length of the gallery quicker than you can turn the head. You can follow it with the eye, but you cannot turn your head as quickly, the violence increases as it progresses. The flame and smoke will shoot out at the end of the gallery 40 feet, hit the massive concrete back-stop, and go up in the air. It is very convincing to the mining men who see such a test. When there is no ignition you do not have the black cloud, merely a white vapor from the explosion in the first valves and light gray clouds beyond.



Fig. 3. Balistic Pendulum for Determining the Relative Strength of Different Explosives.

In Fig. 3, is shown a method of determining the relative strength of different explosives. It is a big mortar, or cannon, which is hung on a pendulum, and the explosive is placed in this. It does not give any positive figure as to foot-pounds of pressure generated, but it does give, by the relative swing, the relative strength, so that you can compare a high explosive with a low one. This arrangement, or a similar one, was designed by Captain Desborough, of the English Mines explosive department.

In Fig. 4 is shown the flame-testing apparatus in which the explosive is placed in a vertical cannon shooting upward. Inside the building there is a photographic machine with a rapidly revolving drum carrying a sensitized film, and as this revolves, it photographs through a slot a series of pictures of the flame. That gives the length of the flame of the explosive, and also, by the number of these successive pictures, the duration of the flame, because the drum revolves at a known speed.



Fig. 4. Building Containing Smoke Room and Photographic Apparatus for Determining Flame Length from Explosives.

Comparing black powder with an average "permissible" explosive, black powder has a flame three to four times longer than the "permissible" and from 3,000 to 4,000 times greater duration. The duration is a very important matter in liability to ignite fire-damp or coal-dust.

In Fig. 5 is shown a gas and dust experimental gallery, in which tests will be made of electric mining machines of the enclosed type. It is also used in demonstrating to miners the effect of fire-damp upon the flame of different kinds of safety lamps.

Another piece of apparatus is for testing safety lamps in currents of different velocities and of various mixtures of gas and air. The lamps are placed in any one of the openings, and the glass door is then fastened. There are hinged flaps above to relieve the pressure of an explosion. There are also certain indicator arrangements by which we can determine the speed and mixture in which the lamp is to be tested. The various positions of the openings into which the lamp is inserted allow testing in horizontal, 45 deg. ascending and descending, and in vertical ascending and descending, currents.

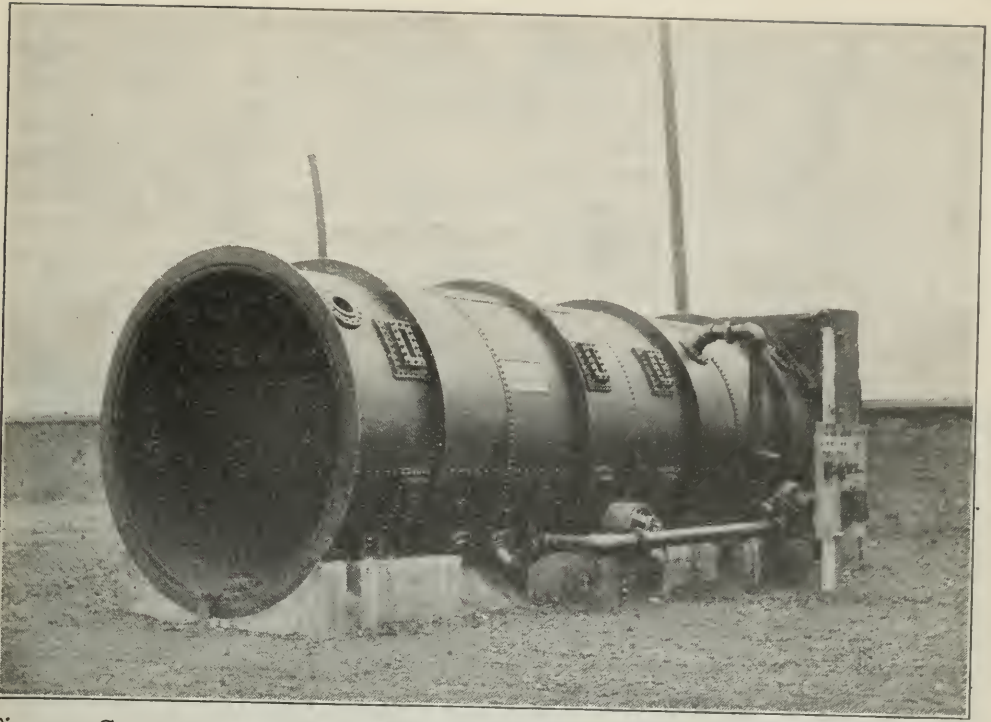


Fig. 5. Gas and Dust Gallery No. 2 for Testing Electric Machines in Gas and Coal Dust.

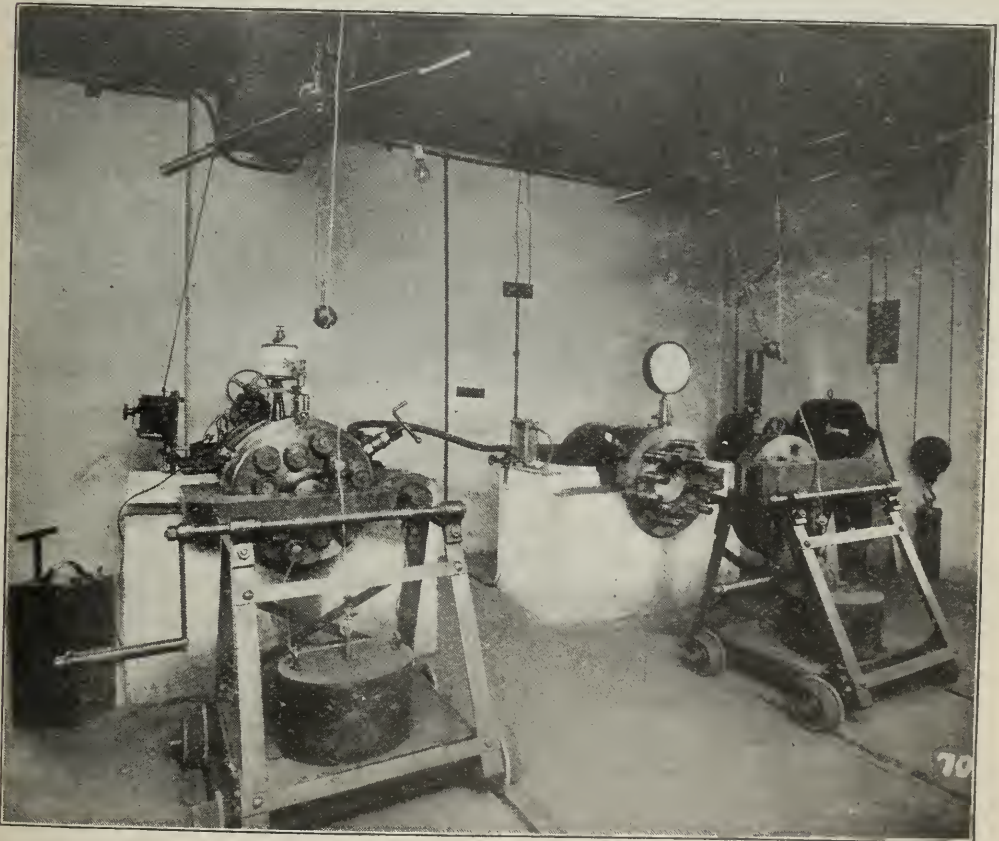


Fig. 6. The Bichel Machine for Testing Gas Pressures Resulting from an Explosion.

December, 1909

Those are all very important things in gaseous mines, because some lamps will stand certain currents and not others. A Davy lamp will fail in about 15 seconds in a mixture of 8% methane; the flame goes right through the gauze, yet the Davy is still the lamp which many of the old-time miners insist is the best. It is indeed very unsafe in a current of fire-damp. The modern lamps will stand as much velocity as we can put on them—about 1,500 lineal feet per minute—and that is as high as they will ever encounter in a mine,—certainly as high as they will ever encounter with an explosive mixture of gas.



Fig. 7. Explosion Calorimeter, for Determining the Total Heat Developed by an Explosion.

The apparatus, Fig. 6, is the Bickel machine, and is for testing the pressure generated by an explosive. We use two of the different sizes, so that there may be a relation obtained between the weight of the explosives used and the cooling surface, of the apparatus and in that way certain variables may be eliminated in the calculations. The explosive is placed in the chamber and exploded by an electric spark. There is a plunger attached to a lever operating a marker, which traces a line on a drum, revolving at known speed, and thus indicator diagrams are made on a card which shows the variable pressure. The latter, of course, jumps up high and gradually descends as the gases cool. A pressure gauge is attached, to obtain the

pressure of the cooled gases. The usual charge of explosive is 50 grams. Figuring to pounds, 1 pound of explosive will ordinarily make about 5 or 6 cu. ft. of the fixed gas. The gases are drawn off and analyzed. This is only a part of the chemical tests of explosives that are carried on.

There is also a calorimeter bomb, Fig. 7, in which the explosive is placed and exploded. The bomb is then placed in a water bath of known temperature and is moved up and down until the bomb and water are of the same temperature. This is to find out the total heat generated by the explosion.



Fig. 8. Interior of Smoke Room, Showing Protective Devices.

A view of the inside of the station, showing the helmet apparatus and oxygen resuscitation boxes, which we found of the utmost value in the Cherry mine is shown in Fig. 8. It would be a fine thing to have such apparatus at various points along the lake shore where in summer there are so many deaths by drowning. In the newer boxes, newer than the one shown, there is a forced respiration. Sometimes men have been revived who have been unconscious for half an hour.

NOTES ON THE CHERRY MINE DISASTER.

On Saturday, November 13, 1909, occurred the greatest mine disaster of the West and, except the great explosion at the Monongah Mine, West Virginia, in December, 1907, occasioned the largest loss of life in any mine catastrophe in the whole country. The exact

December, 1909

figures have not yet been determined but in the neighborhood of 300 lives were lost.

The Cherry Mine is operated by the St. Paul Coal Company, a subsidiary company of the Chicago, Milwaukee & St. Paul Railway. It is located in Bureau County, Illinois, not far from the northern outcrop of the Illinois Coal Basin. Two seams are mined, termed locally the middle and the lower or third vein. Geologically the latter is known as Number 2 seam and the former as Number 5 seam. They are separated by an interval of 160 feet. 40 feet above the middle vein is located the first vein, geologically Number 6. This (No. 6) is a thin, irregular seam in Bureau County and not mineable under present commercial conditions. Furthermore, its area is small as the glacial drift cuts it out in many places in the immediate field.

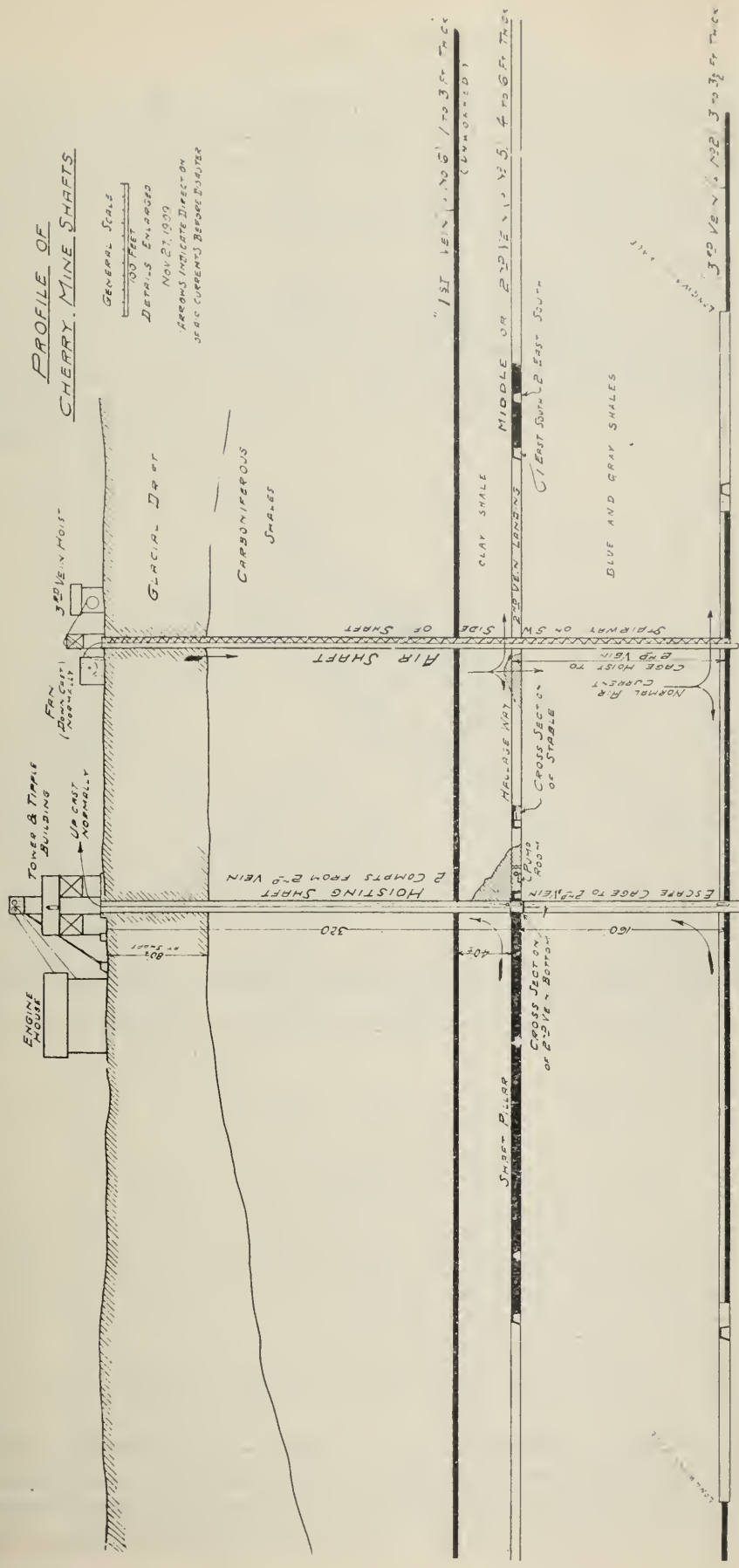
The middle vein is from 4 to 6 feet in thickness, is much cut by horsebacks and rolls, but in the vicinity of Cherry is fairly regular. The quality of the coal is good. The roof is very poor; a clay shale, more or less slippery, and requiring much timbering. This seam was developed four or five years ago and the mine workings are quite extensive covering an irregular area of about 240 acres, the further workings being about three-quarters of a mile from the shaft (10).

In the middle seam the system of working was room-and-pillar. About 300 men were employed in this seam at the time of the disaster.

The lower seam, or No. 2 geologically, was entered about a year ago. It is the seam most extensively developed in Bureau and the adjoining counties. It is from 3 ft. to 3 ft. 6 in. in thickness, with a clay floor, sometimes hard and sandy, and a "soapstone" or a shale roof, bluish gray in color. The 45 deg. system of long wall working is employed exclusively in this seam. At the time of the Cherry disaster the large pillar surrounding the shaft had been blocked out but the long wall work was only fairly started. This work was being crowded and on this account about 200 men were employed in this seam.

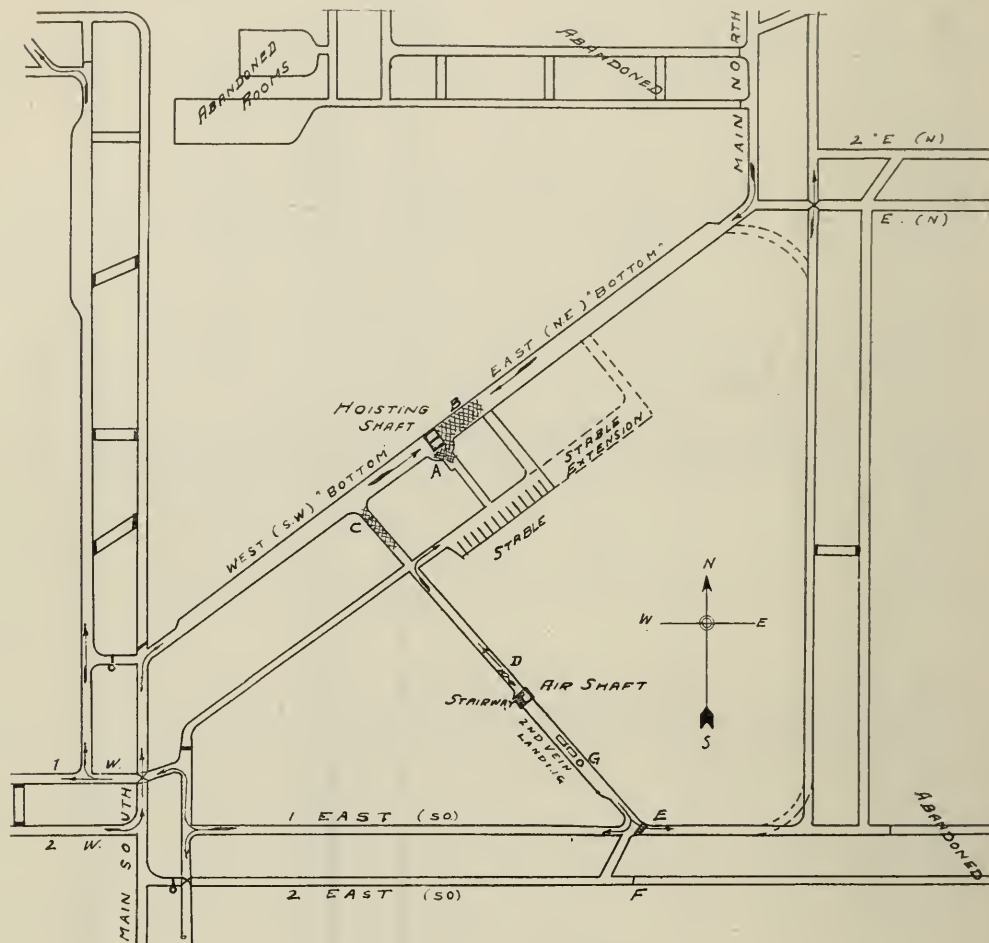
The entrance to the two seams is by a large hoisting shaft and by an air shaft which is also an escape shaft. The middle vein is of limited area so far as workable conditions are concerned, while the lower vein is only limited by the expense of underground haulage to the hoisting shaft. The arrangements were planned with a view to future workings in the lower vein after the middle vein had been finished.

Coal was brought up from the third vein to the middle vein on a cage in one compartment of the air shaft. This cage did not operate above the middle vein, although the hoisting engine was located at the surface. The third vein cars thus brought up to the middle vein were hauled around to the hoisting shaft and hoisted out with the middle vein cars on large cages, on which the 2-ton cars were placed tandem. A stairway runs from the third vein to the surface in one



The Cherry Mine—Theoretical Section.

compartment of the air shaft. In addition to this, as a method of escape from the lower to the middle vein there was a cage in the southeast compartment of the hoisting shaft which could be fastened to the bottom of the main cage by a rope that ordinarily hung from the cage seat at the middle vein.



DETAIL OF SHAFT BOTTOM
MIDDLE VEIN CHERRY MINE
FROM MINE MAP DATED MARCH 31, 1909
REPORTED CHANGES SHOWN DASHED LINES
ARROWS SHOW NORMAL VENTILATION
NOV 27 1909

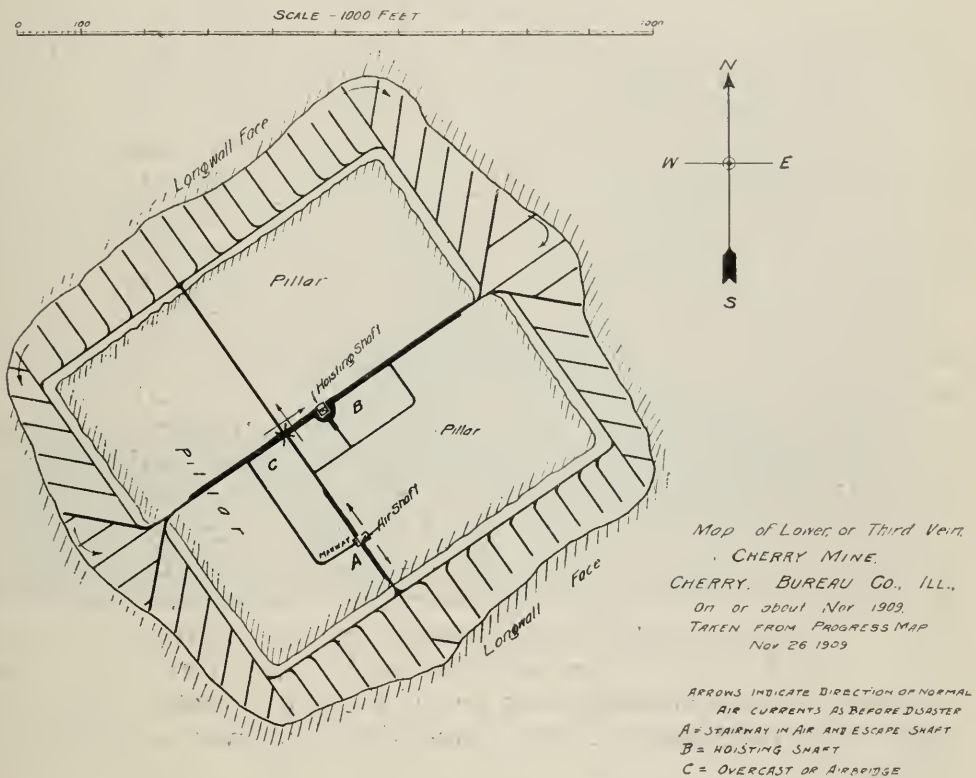
A, B, C = INDICATE FALLS OF ROOF AND FIRE UNDER AND IN SAME
D = INDICATES FALL OF ROOF AND POINT WHERE IT IS PROBABLE TIMBER
FIRST TOOK FIRE
E = TEMPORARY STOPPING OF SAND BAGS WHERE SAMPLES OF
BURNED GASES WERE OBTAINED
F = TEMPORARY BOARD STOPPING
G = LOCATION OF BODY FIRST BROUGHT UP

Partial Plan of Workings and Bottom of Shaft.

The mine was ventilated by a strongly built fan with steel plate casing. It was a reversible fan but as ordinarily used, forced air down the air shaft. The air returned or upcasted through the hoisting shaft. At the middle vein the intake air split, the larger part of

it going through the workings in the middle vein, the other part going to the lower vein workings.

All haulage was by mules and as is the usual practice in shaft mines the stables were placed underground in each seam. That of the middle seam was located about 60 feet away from and parallel with the "bottom." Connection with the bottom was by four crosscuts, one of which was opposite the hoisting shaft and in it was placed a pump. This crosscut was called the pump room. At the mouth there was a "runaround," to pass the shaft from either side. The stable was ventilated by a separate split of air, the main current from the air shaft being shut off by a regulation door between the stable and the air shaft.



Partial Plan of Workings and of Bottom of Shaft.

On November 13th shortly after noon (one witness stated at 1:15 P. M.), a car containing six bales of hay was sent down from the surface and taken off at the middle vein. It was destined for the lower vein. There is some question about the exact route from the hoisting shaft to the air shaft. This point and how it came to be set on fire, whether by fixed torch or lamp in the hands of one of the men, is being investigated by the State Mine Inspectors and the Illinois Mining Commission. For the present it is sufficient to know that it was set on fire after it had been shoved immediately adjacent to the air shaft. In sending the third vein coal around to the hoisting shaft the cars were taken off on the southeast side of the air

shaft; the empty cars going to the lower vein were back-switched through a run-around and put on the cage from the northwest side. From the fact that the timbers on the southeast side are intact and on the northwest side are badly burned and roof caved, I am impressed that the car while burning must have stood on the northwest side. There was said to be hose and water pressure available in the stable. Why it was not used is an unsolved question.

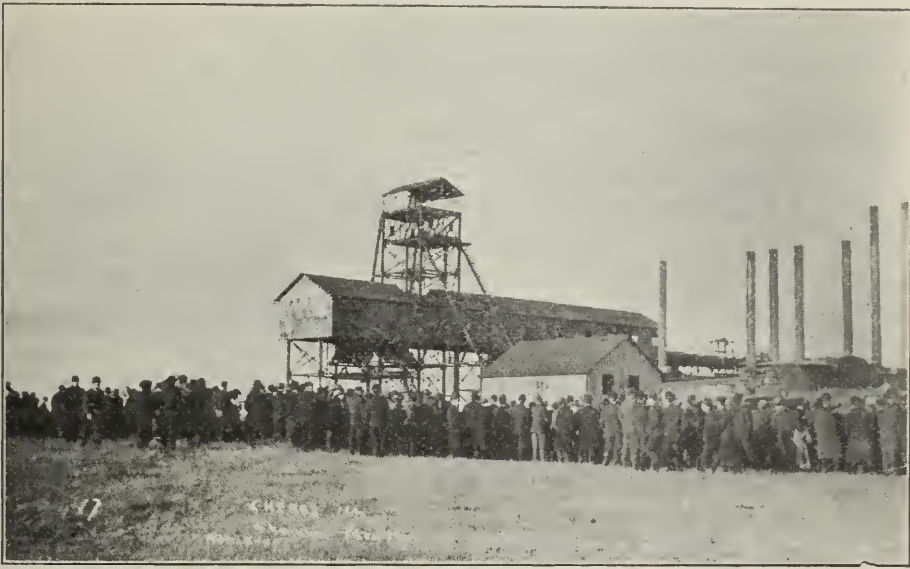
The fire first attracted attention at 1:30 P. M., smoke appearing at the mouth of the hoisting shaft. The writer was informed in the course of the conversation with one of the two cagers in the lower vein and with a driver, who escaped, that about 1:30 P. M., they heard a cry from the middle vein landing at the air shaft, that a car of hay was on fire. The cager states that he called up to throw it down into the sump, and looking up into the air shaft he saw flames. He told the other cager he would go up and help throw it down. The driver agreed to go with him. There were three feet of water in the sump and before going they told the other cager to connect a hose with a water tap at the foot of the shaft to play water on the burning car of hay when thrown down. They went up the stairway, 160 ft. vertically, and on arriving at the middle vein landing they state that there was no one near the burning car.

There was one burning bale standing in the middle of the road behind the car. (Another party claimed that there were two burning bales out of the car.) They stated that the car itself was on fire and so badly burned they thought there would be very little found of it in the sump. The front of the car extended on the cage and they belled to raise the cage. The engineer at the surface testified that he received the signal and raised the cage about four feet. This allowed the car to drop past the cage and down the shaft into the sump, where the remaining flame, they claimed, was put out by hose. It has been stated that throwing the car down into the sump was the chief cause of the extension of the flame through the mine. As the shaft was naturally wet and if there was water in the sump and a hose ready below, I cannot feel that there was any risk in this action.

The cager and the driver state that seeing the timbers were set on fire in the middle vein and that they could not put out the fire, they went below to give warning, claiming that they ran around a considerable part of the lower vein workings before they considered it necessary to run for their own safety. The cager stated that he was the last man that came out of the stairway and when some distance from the top the fan was reversed making the air shaft an up-cast, and he had to come up through smoke, barely getting out. His "buddy" or partner cager was lost. While this information is of a hearsay character, it is necessary to give it, to obtain the proper understanding of the subsequent conditions.

Meantime, at the surface, the smoke was observed at the mouth of the hoisting shaft. Ten or twelve cage loads of men were brought

up on the cages. The underground managers of both veins happened to be on top. These men went below to assist. The third vein manager, Norberg, subsequently came up and it is stated that a signal (six bell) was received to reverse the fan. He and the air shaft engineer and the machinist went over to the fan and reversed it. Norberg then went below, telling the hoisting shaft engineer that he was going to attach the rope of the third vein cage to the southeast main cage and to watch the signals closely. Norberg was accompanied by nine or ten other volunteer rescuers, but after a few minutes on the bottom the flames had become so strong that evidently they could not proceed and belled to come up. When the cage was about 25 or 30 feet off the bottom signal was given which caused the engineer to stop the engine.



Coal Tipple at Cherry Mine After the Alarm of Fire.

Bearing in mind the injunction of the manager, he held the cage for some time, which he thought was 5 to 10 minutes, waiting for other bells. This stoppage most unfortunately caused the death of ten rescuers who were overcome by the smoke and flame. On the other hand, the engineer could not know what was going on underground and supposed that they might be attaching the third vein cage. It seems probable that the rescue party, finding they could do nothing, had belled to return to the top, but some poor fellow coming out after they had started, had strength enough to signal for stopping and lowering the cage, but not enough strength to signal for raising. One body was found in the sump. The system of signaling is by a pneumatic gong.

As to the merits or demerits of reversing the fan, at the particular time, that is a debatable question. There is one disadvantage in having a reversible fan,—there is always a tendency to reverse whether it is the proper thing to do or not, and usually it is not. Men nat-

urally go towards the incoming air after any fire or explosion. If the current is reversed it throws the smoke or gases upon them. In this case could the reversal have been made at once when the fire started it would have sacrificed the air shaft but kept the hoisting shaft from catching fire, but at the time it was done, unknown to those above, it was too late. The fire had already been carried to the hoisting shaft. Subsequently, it was undoubtedly better that the hoisting shaft remained relatively intact so that it could be used in the rescue work. It is apparent that the flames started in the timbering in the middle vein air shaft were rapidly blown towards the hoisting shaft prior to the reversal of the fan and set fire to the stable, pump room and northeast side of the hoisting shaft, since the timbers on the southwest side of the hoisting shaft are very little burned. The doors in the crosscut leading to this bottom evidently retarded the flames in that direction until the air currents were reversed. On the other hand, in the pump room and on the northeast side the timbers were so badly burned that subsequently the roof fell almost to the edge of the shaft.

The fire did not penetrate to the lower vein but the smoke and gases were blown around and probably the larger number of men quickly succumbed. From the notes they left, some evidently lived two days. The fire in the middle vein was limited to the immediate vicinity of the hoisting shaft, the pump room, the stable and the entry leading to the air shaft. In the air shaft from the middle vein to the top the flames burned the face of the linings and projecting timbers, but except for 30 to 40 feet at the top and bottom there was no serious damage done to the lining. The flames passing through the fan heated it red hot, so that it was practically burned out for operation purposes prior to 4 P. M. At this time the tower over the air shaft, which was of wood, had been badly burned so that it was subsequently removed. Smoke was also coming out of the hoisting shaft.

About this time, 4 P. M., it was decided to seal the main shaft, which was done by placing iron rails over the top and covering these with plates and then with sand. Meantime water was played down the air shaft. The active flames having been put out, a light was lowered in the air shaft, but on account of smoke nothing could be seen.

Mr. R. Y. Williams, Mining Engineer of the U. S. Geological Survey, stationed at Urbana, Illinois, had been notified late Saturday evening. Hastily gathering the rescue apparatus and taking his assistant, Mr. Webb, he started for Cherry, arriving Sunday morning by special train. A pulley was rigged over the air shaft and a rope attached to the air shaft hoist engine and a hole broken in the roof of the fan conduit so that a descent could be made in a small bucket.

At 1:20 P. M., with a volunteer helper, Joseph Smith, both using helmet oxygen rescue apparatus, Mr. Williams made a descent into the air shaft, going down about 60 ft. The sheave proved not to be

centered so that the descent could not be continued. On this being remedied a second trip was made about 2 P. M. by Messrs. Williams and Smith. This time they got down about 250 ft. where it was thought that the shaft lining had broken as the bucket landed on an obstruction. It was so smoky that nothing could be seen. In investigation several days later this obstruction was found to be an offset behind which ran a counterweight for the third vein cage. However, at the time it was concluded that it was something that had to be cleared and weights were placed in the bucket and it was run up and down several times to clear the supposed obstruction.



Top of Shaft Closed to Smother the Fire Below.

A third trip was undertaken about 5 P. M. and this time Messrs. Williams and Smith went to the second vein. They found smoke coming out along the roof with considerable velocity. Below the heavy smoke cloud they could see in about 10 ft. either way, and at the northwest side could see a fall coming nearly to the shaft. The temperature at the level of the vein was 68 deg. Fah. Twenty feet above this it was 76 deg. Fah. The bucket was so small that only one foot could be placed by each man in same, and owing to the weight of the apparatus, which is about 45 pounds, in addition to an electric lamp weighing 15 pounds, it was necessary to tie in the men, to prevent their falling out. This prevented any examination at the middle vein, more particularly too, because there was no landing, that is the bucket swung in a large shaft which went down 160 ft. deeper.

About 11 P. M. the air shaft was sealed. It was then "out-taking" quite strongly. Next morning, November 15th, the cover was taken off the hoisting shaft, the State Inspectors having meantime arrived. Mr. R. Y. Williams and Mr. Moses, State Inspector from the Danville District, using helmets, went down on the cage in the hoisting shaft about 9 A. M. They reached the second vein. It was so

smoky they could not see, but they got about 25 ft. from the shaft in the middle vein on the southwest side before coming up. The timbering in the northeast bottom was then standing. It was too smoky to see into the pump room.

The air shaft at this time was covered but immediately afterwards the cover was removed and a steam jet put in to cause the air to up-cast. Mr. Webb, Mr. Williams' assistant, and Mr. James Taylor, State Inspector from Peoria District, in helmets went down in the hoisting shaft about 10:30 A. M. They explored about 150 ft. to the southwest. It was still too smoky to see, so they returned to the surface. The fan was then repaired and started upcasting. Messrs. Webb, Taylor and Moses descended the hoisting shaft about 11:30 A. M. using helmets. They saw fire and came back for a conference.

Meantime, Messrs. Williams and Webb went down with hose, which had been connected to a R. R. tank car, and saw three fires, in the pump room, in the corner of the cribbing in the south compartment of the hoisting shaft and in timbers on the northeast bottom 15 ft. from the shaft. The air was much clearer and although smoky they could see fairly well. They opened the nozzle of the hose but could not get any stream that would throw more than a few feet. They left the hose turned on and came out to see what the matter was, using the north cage. It was concluded that there was something wrong with the valve and Messrs. Moses and Williams again went down to try and use the hose. They did not get to the bottom, for although only 10 or 15 minutes had elapsed, the fire at the bottom was crackling strongly and big falls were taking place. When they came up arrangements were made to withdraw the hose. They went down about 50 feet to the first joint to connect on tackle and then returned to the surface.

It was decided by the State Inspectors to re-seal the shafts. Messrs. Paul, Morris, and myself, arrived at this time, about 12:30 P. M., November 15th, from the Pittsburgh headquarters. Several conferences were held. It was reported that the air shaft was inaccessible on account of the supposed dangerous condition of the lining, and the arrangements not suitable for working therefrom. The hoisting shaft was evidently on fire at the middle vein. It was decided to put a sprinkler into the hoisting shaft by suspending a hose in the middle of the shaft and attaching a perforated nozzle at the bottom. This was made during the night and the following morning the boiler room pump was started. Much smoke and gas leaked through the shaft covering and the temperature just below was 110 deg. Fah.

That evening, November 16th, a company of firemen from Chicago arrived, in charge of Chief Horan, bringing a fire engine with them. It was decided to throw water with this down the shaft. It discharged about 600 gallons per minute. The sprinkler had been supplied with only 80 gallons or less per minute. The hoisting shaft

still showed an upcast pressure, the smoke and vapor leaking through the covering. Frequent readings were made of the thermometer which showed the temperature to be from 110 deg. to 115 deg. Fah. both at the top and bottom of the shaft.

The following day, November 17th, it was decided to investigate the air shaft, as the thermometer showed that the air in it was of practically normal temperature, although the gases it contained put out a safety lamp. Mr. R. Y. Williams and myself were prepared to descend that evening.



Fanhouse Mouth of Shaft and Tibble at Cherry Mine.

After getting into the bucket and being lowered just below the top to complete the tying in, the writer found he so much outweighed Mr. Williams that the small bucket was tipped at so much of an angle that he would not be able to slide past obstructions, hampered with the heavy rescue apparatus and the electric lamp. Mr. Morris, of the Survey, who weighed about the same as Mr. Williams, volunteered to take my place and these two were slowly lowered to a point just above the middle seam. They reported that the air temperature was normal, and except for the slight smoke and haze, it was fairly clear at the level of the vein.

In subsequent conference it was decided that a float, or small wooden cage without guides, be constructed and a small tower erected, so that efficient work underground could be done from the float. These were built during the night and following morning, under the supervision of the writer, and early in the afternoon of November 18th, Messrs. Paul, Williams, and the writer, incased in helmets, went down on the float, the top of the shaft being recovered with canvas. Signals were given with an automobile horn. We were able to effect a landing at the middle seam. The atmosphere

was clear except for a slight haze at the roof level. Mr. Paul went southeast on the bottom of the turn, finding a body a short distance from the shaft. On the northwest side a heavy fall blocked the way. A careful examination was made of the shaft lining in going down and ascending. The whole trip occupied about 35 minutes.

It was found that work could be done from the air shaft but in the subsequent conference it was decided that in view of the conditions, the fan could again be started upcasting and the fire directly fought at the hoisting shaft. Before doing this, however, Messrs. Moses, Taylor and McAllister, State Mine Inspectors, put on the helmets and went down in the float, bringing up the first body recovered.

That evening the fan was started, the cover was removed from the hoisting shaft and a hose played from the top by the firemen. Subsequently, as the shaft became cool from the water and from the incoming cold air, the hose was carried down gradually to the bottom, where an entrance was effected on the southwest side. Falls had occurred close to the shaft on the northeast side and in the pump room entirely closing the openings in these directions and also temporarily blanketing the fires.

The following day, November 19th, a considerable number of bodies were recovered from the shaft bottom and vicinity. The mine inside was found to be cool but full of black-damp, which had to be slowly forced out by the air current. The plan adopted was to clean out one pair of entries at a time. Movements were hampered by the dead bodies of mules and loaded cars, which were more or less blocked by the mules and by falls here and there. Investigation made to the southeast of the escape shaft disclosed the fact that a current of hot gases and smoke was entering from the east side. This evidently came from the fire under the fall at the northeast of the main shaft and from the stable, and was carried around the shaft pillar until it entered the air shaft bottom. The opening was partly closed by a stopping made of bags of sand.

Meantime, investigation was proceeding on the south side of the mine and to the west.

It was felt that the fire was under control, and as the search for bodies was being actively prosecuted by regular shifts of men, the State Inspectors thought it would be safe to return to their respective districts, where there was urgent call for their services. Mr. Paul of the Survey also left for Pittsburg.

Owing to the bad air encountered at the foot of the shafts and the length of time that had elapsed, it was not considered possible that anyone trapped in the mine could be alive. Nevertheless, early in the afternoon of the following day, November 20th, Mr. David Powell, who was in charge of the underground work, happening to enter the second west entry on the south side, heard a noise and going inward with a shaded light, he was greeted by one of a party of eight men who had been entombed since the start of the fire, and had saved themselves by erecting barricades near the heads of the

in the
point
half
lark-
ort a



that
ough
nets,
riter,
short
sing.

As
with
d he
later
been
oxide

outh
good.
mos-
was
arri-
black
cloth
been
one
men



Cherry Mine—Plan of Workings of Lower Vein.

first and second west entries. They had just made holes through the barricades and had come out through the black damp, to the point where discovered by Mr. Powell. This is a distance of over half a mile that they had to work past cars and dead mules in the darkness, and in an atmosphere which in places would not support a light.



Rescuers with Protective Apparatus at Cherry Mine.

They arrived in comparatively good condition and reported that there were twelve more men behind the barricade not strong enough to come out by themselves. There was at once need of the helmets, and willing volunteers accompanied by Mr. Williams and the writer, entered the mine. Since the range of the helmets is relatively short it was advisable to carry them in as far as was possible before using. Meantime, an air current was being forced into the second west. As Mr. Williams was the most experienced and efficient operator with the helmets, the writer concluded to hold him in reserve, and he waited at the mouth of the entry in comparatively fresh air, later being joined by Mr. Webb. Meantime the air current had been slowly forcing the black damp, which is a mixture of carbon dioxide and nitrogen, toward the face of the entry.

We were able to penetrate up to the mouth of the seventh south stub-entry, without using the helmets, although the air was not good. Beyond this point the light would go out instantly, and the atmosphere was bad. It was none too good at the base selected, but was breathable. The first volunteers were able to get up to the barricade, but could not get through same with the helmets. The black damp from the eighth south entry was very strong, so brattice cloth was sent for and erected at the mouth of this entry, as it had been reported by the leaders of the rescued men that there was no one in it. The hole in the barricade was enlarged so that the helmet men

could go through it and one after another of the miners who had been besieged behind it, were brought out, some of them supported by the helmet men but a few were able to come by themselves.

One oxygen resuscitation box had been brought in to the base at the seventh south, and this was applied to the most exhausted men, as well as the rescuing brigade, who overworked in the warm atmosphere and some of whom did not have the helmets perfectly adjusted. None were experienced in the use of the helmets, and the fact that they did so well was most creditable and praiseworthy.

Meantime a line of men had been made all the way back to the shaft at frequent intervals so that help was given all away along the line to the rescued men. Finally all but one man was brought out. At the time it was thought there was another. Mr. Williams came up and with a volunteer went in and after great difficulty this time could be reached without helmets. Here oxygen was administered both to the rescued man and the rescuer. As stated it managed to drag this helpless man to the barricade, which by was thought at the time another man was inside and the writer and Mr. Webb were preparing to go in when information was brought from the leaders of the rescued, that all had been accounted for in the vicinity. The retreat was then made and the body, that of a Frenchman named Paul, found in the vicinity of the fifth and sixth stub, brought out. These entries were then closed with a brattice and the air turned into the south entries, where the following day a large number of bodies were found. These men had shown much ingenuity in making fans, but unfortunately the idea of barricading had not occurred to them, as it had to those in the first and second west entries. From the notes they left, they had evidently not lived after Monday, or at least were not conscious.

The story related by the rescued men is of extraordinary scientific, as well as human, interest. As related to the writer by one of them, Salvatori Pigatti, condensing and translating his broken English; he states: I worked in the straight second northwest entry. Did not know about the fire till 3 o'clock Saturday, when I smelled smoke; went toward the bottom (distant $\frac{3}{4}$ mile) the air getting worse; tried to get into the first east on the south side, which runs to the escape shaft, but too much smoke; met other men at mouth of second west south side; there were twenty-one of us in all; we retreated up this entry to the fifth and sixth—south stub entries, where we stayed some time; came out to near mouth of second west several times, but had to go back. There was a Frenchman, named Paul, who felt very badly. He said he would go to the bottom and send assistance if he got there. He didn't come back, so we followed and found him near the sixth-south entry dying. After he died we were driven in by the bad air to near the head of the second west entry, and on Monday began to build two walls, one across second-west, and one across the back-entry or first-west. These were located just outside of the haulage crosscut to the ninth and tenth-north stub. The walls

were built of stone, powder cans, and mud. Up to this time the lamps burned, though dimly. We had plenty of oil and matches, a kerosene torch which burned low, and two small acetylene miner's lamps. When the stoppings were complete, our oil lamps and kerosene torch would no longer burn; we could still keep an acetylene lamp burning. But on Tuesday this went out and we could not re-light it; the matches would not burn. We were four days in the dark. We got water by digging holes in the floor, particularly in the rooms off the tenth-north stub, and by doing this were able to dampen cloths. We got so little water and were feeling so thirsty we decided to go to the bottom to try to get water before giving up. I dug the hole through the stopping in the second-west, and another hole was dug through the stopping of the first-west. I had a terrible headache when I finished. Four of us started, and then four more followed. We had a hard time going along the entry; there was a terrible smell as we went past dead mules and it was hard to climb around the cars. Finally we saw a light, then many lights, and came on officials near the mouth of the entry.

Scientific interest is awakened by this demonstration of the possibility of sustaining life for five days when oil lamps will not burn. Such oil lamps go out when the percentage of oxygen in the air falls below 16%. Normally there is 20%.

It seems extraordinary that with upwards of 5% of carbon dioxide (CO_2) in the air, life could be so long sustained. It seems probable that there cannot have been any carbon monoxide (CO) present inside of the barricade, as the effect of this is poisonous, the haemoglobin of the blood absorbing same and thus preventing the absorption of oxygen. When the haemoglobin becomes 80% saturated, death results. According to Haldane, with long exposure anything above 0.15 of 1% is dangerous. With 0.4 of 1%, death ensues in a short time.

At the face of the northwest entry a sample of air was obtained by the writer which showed 0.3 of 1% carbon monoxide (CO) as determined with an Orsat apparatus.

To return to the narrative. The search in the south side of the mine was actively pursued that night, but with no more fortunate finds. The State Inspectors returned to Cherry the following day, November 21st.

The fires in the vicinity of the hoisting shaft gave more or less trouble. An attempt was made to push an entrance under the fall on the northeast side of the shaft, but the tumbling roof threatened to slide over and squeeze the shaft, as it did on the pump room side, making it difficult to get the southeast cage to the landing. The return from the fires passed around the east side and thence through the partial stopping of sand bags, previously mentioned. A pipe was placed through this stopping and the latter made tighter. We took frequent readings with the thermometer, finding the temperature was 103 deg. Fah., increasing later to 107 deg. Fah. Samples of the

gases were frequently taken and analyzed on an Orsat apparatus for CO₂, CO and O. Unfortunately it did not have a Methane attachment.

	11/21 2 P. M.	11/21 10:30 P. M.	11/22 11 A. M.	11/22 4 P. M.	11/23 10:30 A. M.	11/24 10 A. M.
C O ₂	4.5%	4.1%	4.5%	4.6%	5.8%	7.0%
O ₂	14.2	14.4	14.3	15.4	12.9	10.3
C O	0.3	0.4	0.4	0.3	0.2	0.3
	19.0	18.9	19.2	20.3	18.9	17.6
	20.9	20.9	20.9	20.9	20.9	20.9
Unaccounted for . . .	1.9	2.0	1.7	0.6	2.0	3.3

It will be noted that as the stopping was made tighter the percentage of CO₂ increased. It will also be noted that there is unaccounted for, 0.6 to 3.3% ; whether this was due to formation of methane or other hydro-carbon gases, or to absorbtion of oxygen by the coal and roof material, is a question.

By the evening of November 22d, the middle vein having been explored, except for the northeast section, on the other side of the fires, with no approach except through the fires, it was proposed to explore the lower vein. Mr. W. W. Williams, a State Inspector, and the writer, made arrangements for the exploration. Having gone to the middle vein, the southeast cage was lowered and after some difficulty the rope of the third vein cage attached. This was then brought up to a landing about fifteen ft. below the middle vein landing. The entrance to the former was blocked by the heavy fall northeast of the shaft so it was necessary to reach the cage by going down the rope. Having tested the air by lowering a thermometer and safety lamp, (there was a strong current of fresh air going down), Archie Frew, Bernard Doughty and Robert McFadden slid down on the cage, and were lowered. They found three feet of water on the bottom, but waded to the overcast as it was suspected there would be the most likely place for living men. None were found, only a few buckets showing some had been there at one time. They then returned to the cage, but on hoisting the main cage stuck, after making efforts to get it past where some projecting rivets caught the shoe, and the men became so chilled from water falling from the water ring in the shaft and the temperature at 38 deg. Fah., they climbed the slippery buntens for over a hundred feet vertically. On reaching the under-landing, a sling was made to pull them up one by one through the hole in the cage seat. The cage was then lowered and the third vein cage detached. The main cage then passed the obstructions which were subsequently removed, —and regular hoisting resumed. The remainder of that night and next morning, November 23d, the attack on the fire around the shaft had to be renewed. The search having been completed on the south

and west side, an effort was made to reach the east side through an abandoned road. This failed, as the road was found to be caved in. A momentary panic was caused along the line of men stretched out for half a mile by an order to come out on account of the condition of the fires at the bottom, which were attacked by the firemen at several points through the shaft lining, the smoke issuing at times 24 ft. above the floor, indicating the height of the fall.

On the morning of November 23d, the southeast cage being made to run freely, the third vein cage was again attached and a party of four sent down to explore the third vein. They found from 150 to 169 bodies, the count varying. Some of the men had made fans from drill machine parts. Canvas curtains has been hung but no walls erected. None of the notes found indicated the men had been conscious after Monday following the fire.

Following this exploration it was decided that to get out the bodies it would be necessary to install a pump. While this work was being arranged, the fires at the hoisting shaft were causing trouble and that night, at 3 A. M., November 25th, it was decided by the State Inspectors, and Mr. Richard Newman, Chairman of the Illinois Mining Commission, to seal both shafts for awhile to obtain control of the fire.

What lessons are we to draw from this and other like disasters?

First, the danger of having combustible material taken down wood-lined shafts and into timbered passageways.

Second, the menace of having the approaches and the exits themselves of combustible material.

Third, the danger of reversing a fan when those above do not know all the conditions underground at the moment of reversal. This may or may not have been a matter of moment in the present instance, but the danger is brought to notice.

Fourth, the importance of having ample fire-fighting equipment and systematic drilling.

Fifth, that escape facilities suitable for a mine with 100 underground workers may not be suitable for 500 or 600 workers. The depth of the workings should also be taken into account. Stairway exits which are required by the present Illinois law while suitable for shallow seams, may not be, for deeper seams, except as an auxiliary means. It may be desirable where the number of men underground is very large and the works extensive, to have an additional escape shaft, preferably with non-combustible lining and neutral so far as ventilation is concerned.

Sixth, that fireproof underground rescue chambers, supplied with food, water and means of communication to the surface, preferably with an open drill-hole would be of inestimable value. Such chambers are used in some of the German mines, equipped also with oxygen self rescue apparatus.

Although brick and concrete shaft linings and bottom archways are universal abroad, they are not used in this country.

The writer refrains from discussing these matters in detail as they are now being investigated by the Illinois Mining Commission.

Safety features cost money. With the present unhealthy competition in the bituminous industry of this country, drastic improvements in existing mines would drive operators to the wall. If, however, a larger margin of profit was obtained, many of the safety features could be required that are employed abroad, where much higher prices are obtained in marketing the coal. Moreover, the mining laws in our competitive states, at least, should be uniform so that all operations would be placed on the same basis.

As to the widows and orphans of the victims of either small accidents or large disasters, the writer believes that their maintenance and education should be as much a part of the cost of producing coal as is the food and clothing of the living workers. The coal consumers should gladly pay the added cost of this. In other words, there should be compulsory accident insurance carried by the industry as there is in Germany.

DISCUSSION.

Mr. A. Bement, M.W.S.E.: While I shall say but a few words, it may be well to state that certain features which are of vital importance, present themselves in connection with the lamentable disaster at Cherry and if my directing attention to them is of any avail, I shall certainly feel gratified.

Coal mining has always been considered a hazardous business and occupation, for this reason it has been deemed essential that those engaged in it exercise great care in the prosecution of such work, because it has been felt that entire safety could in no other way be insured. But serious disasters have occurred from time to time, notwithstanding the effort made to avoid them, with the result that new departures in the conduct of mining enterprises tending to greater safety have been adopted voluntarily, as well as enforced by law, with the result that greater safety has been insured, or, in other words, that safety has been made more and more automatic. We are now in Illinois at one of these epochs and at face with a prospect of serious nature. A state mining commission has been recently appointed by the Governor and it will necessarily follow that the result of its investigations, as well as the demands of popular opinion, may require great changes in the character of mining plant, as well as in better methods of operation, with the result that the cost of production will be increased. This in itself is not objectionable. But the enforcement of such requirements as are necessary and desirable, by the State of Illinois only, will result in such increased cost of production that the coal industry of this state will be at a disadvantage with other producing centers. Thus Indiana for example, would probably not follow Illinois in enforcing the same regulations, with the result that this state will lose business to Indiana which would have a lower production cost. This fact is not stated as an argument

against provisions for greater safety, but to emphasize the absolute necessity of the enactment of Federal legislation which shall apply to mining in all states alike. In this way mining methods over the entire country may be improved, which will be difficult if not absolutely impossible to secure by individual state regulation.

I am aware that the establishment of such an act by the general government must be backed by strong public demand. The justice and necessity for it however is obvious, not only as affecting matters of safety but also that of the conservation of our natural resources. Under present conditions in the majority of the coal fields of the country, a very large percentage of the coal is left in the ground and lost. This coal is left because it would cost more to remove it than it does to mine the coal that is taken out. Thus competition enforces a process of robbing, resulting in a waste of resources which amounts, at present day prices, to between \$100,000,000 and \$200,000,000 per annum. In addition to this the large amount of timber used in shaft linings, supports at the shaft bottom and on main roads, is a serious drain on timber resources, as well as a continual invitation to the repetition of such catastrophies as that which has just shocked the community. There is no question but that the time has now arrived when for other reason than that of safety, a more permanent material, such as concrete, for example, should be employed for shaft linings, on shaft bottoms and on main roads where the roof must be supported.

Mr. Rice's suggestion for a separate escape shaft is a good one; under the present Illinois law two openings are required, which shall be not less than 300 ft. apart. With shaft mines this requires two distinct shafts and the employment of an opening exclusively as an avenue of escape, suggests the necessity of three distinct shafts, which would very materially increase the cost of the plant. By the employment of concrete however, if the rectangular form of shaft be adhered to, the hoisting, air and escape shafts may be combined in one, being separated by concrete walls, the whole being fireproof. By means of approaches to the escape shaft leading from a little distance to it, entrance could be had without entering it at the shaft bottom proper. Likewise at the top, exit leading away from the tibble would be feasible. Another advantage of an independent escape shaft, or man way, is that it would not be necessary to move air through it for ventilation of the mine, a matter, under some conditions, of great advantage.

Regarding the employment of the oxygen helmets, I should like to say a word. In no case as far as I am aware in this State, has adequate facilities been found that would enable effective service to be obtained. There have been cases where even a rope to let the men wearing the helmets down into the shaft was not available. Letting men down in a small bucket is an entirely inadequate scheme. On the occasion of a fire in the mine at Zeigler, Ill., two men wearing helmets were lowered in a bucket which caught and hung on an ob-

struction till several feet of the cable became slack, when the bucket which was resting at an angle, was dislodged and dropped the length of the slack of the cable. When men are loaded with 40 pounds of helmet, 15 pounds of electric lamp, in a smoke filled shaft in absolute darkness, an experience of this character is not liable to increase confidence as they attempt to explore the workings of the mine.

The foregoing suggests the desirability of a suitable device in which helmet men may be lowered, which would be afforded by surrounding a small platform with an iron open work cage, high enough to come up to the men's heads and provided with a door or gate which they could easily close and fasten. Such a small emergency cage, together with suitable cable, simple hand windlass, properly mounted pulley over which the cable may run and a signal rope, are necessary adjuncts to effective use of helmets.

Mr. R. Y. Williams: I would like very much to tell some of my troubles, general and specific, in connection with the rescue work. Thus far only one mining company has sent anybody to the station to be trained; one Illinois company sent three men for training at our station in order that their shaft or mine might be entered with the aid of the helmet. Consequently there are very few people, or none at all, when we come to a disaster, who know anything about a helmet, know anything of its use, advantages, possibilities, or its limitations. Therefore it is difficult for us, from the Urbana station, to render efficient service. For a specific case we will take the Cherry mine as an example. The call came at midnight. I had no assistant. Our appropriation is not large enough to warrant the employment of an assistant, and the operators of Illinois have considered it unwise to furnish funds to employ an assistant. But I called a gentleman who has at times acted as my assistant, and found him sick in bed; he was willing, however, to get up, help pack the equipment, and go with me. We prepared our 1,300 pounds of baggage and reached Cherry in a very quick time—9:35 A. M.

The area covered by the Urbana station is very large—Illinois, Indiana, Iowa, Western Kentucky, Michigan and Missouri. This territory keeps me busy; there is a limit to human endurance. When we arrived on this morning we had had no sleep that night, no breakfast that morning, and my assistant was sick. The first requisite was an understanding of the situation, to learn just what had happened; the next, planning of the rescue work and arrangement of the details of getting a rope from a slag pile and hitching a bucket to it; also erection of a head frame, mounting a sheave and other things. I had to examine the helmets myself, wear them in the mine, and make investigations in a strange mine where I knew nothing about prevailing conditions. For example, a blockade was encountered, of which we had not been informed before going down into the mine. Had we known of it, much valuable time would have been saved.

If we start in and do the actual work ourselves, as we usually have

to when the volunteers have become exhausted—although the volunteers at Cherry deserve a whole lot of credit—we know that if anything happens there is no way of anybody coming after us, because there is no one who knows how to handle the helmets. If it could be arranged so that my assistant, when we go to a place, could be isolated in a room and have nothing to do but watch the details of the instruments, there would be absolutely no chance of an instrument getting in use in an imperfect condition. If I could be with the inspectors and the company's men, and help to plan the actual work that the helmet wearers are to undertake, I believe I could do much better service.

The matter of physical strength is important. I have laid track, and done other hard work, but that was a long time ago, when I was getting my actual training. I have also timbered, but that was during my apprenticeship. So, when it comes to work of this kind, it is a little hard to pitch in and do anything like the work that can be done by a man, for example, of the Chicago fireman type, whose muscles are hard and who are trained. If the mine-examiners and some of the workmen, and a few other willing young fellows—handy men—were trained to use the helmets, they could do good work and our results would be better, because we would have men who are trained, are physically capable, who know the mine, and who could wear the helmet.

Just as an illustration of what is expected, I want to mention what came up last Monday. In the morning I received a telegram from Mr. Rice, asking me to investigate and report on the Eldorado explosion, which was a bad one, although the death list was very small. In the afternoon, right after lunch, Linton, Indiana, called up and said a mine was on fire at the shaft, and wanted us to go right over. I replied that there was no train until night which made connection. I had just hung up the receiver when a call came from DuQuoin, Illinois, asking us to come down and help put out a fire. It transpired, however, that they did not know whether there was a fire or not, as the mine had been sealed three or four weeks, and they wanted us to open it right off and find out. Then a newspaper was handed me containing an account of the Marion fire, which might need the helmet. It seems to me there is certainly a good chance in Illinois for a few rescue stations besides Urbana.

Mr. W. L. Abbott, M.W.S.E.: I do not think a layman should take up the time of this audience to-night in the discussion of this very interesting subject; but I would call the attention of the Society to the fact that something less than a year ago, at the instance of the coal operators, this Society petitioned the legislature to make an appropriation to establish at the State University a department of Mining Engineering, particularly for the purpose of investigating and improving the engineering work of our coal mines. Because of the representations made by this Society and others, the legislature made such an appropriation and the department of Mining Engineering in the University of Illinois has been established.

We have here tonight the professor who has been placed in charge of that department, and I would like to have you call on Professor H. H. Stoek, of the University of Illinois, who is also a member of the Illinois mining commission, and is officially interested in the subject, which is being discussed here to-night.

The Chairman: I take great pleasure in calling on Mr. Stoek, and ask him to say a few words.

Prof. H. H. Stoek: Mr. President, I had no idea when I came here that I was to be called on, and Mr. Abbott has also given me a cue that the cage from this floor stops at eleven o'clock, so I will promise not to speak very long.

In the first place, I wish to commend, most strongly, the work that was done by the helmet men and other rescuers at Cherry. On behalf of the Illinois Mining Investigation Commission, it should be stated that although some of the daily papers reported that the members of the Commission were not attending to the duty imposed on them by being at Cherry, yet six of the nine members were at Cherry the greater part of the first week, investigating and trying to get data for future use. You will probably be interested in knowing also that measures are being taken to investigate the causes of the trouble at Cherry, with a view to making recommendations to the next legislature for a revision of the mining laws. The first investigation is necessarily that made by the Coroner, and that is in progress at the present time. It began on Monday and the preliminary part that is now going on, amounts simply to the recognition of the bodies that have been taken out of the mine. A joint investigation of the causes of the disaster will be begun tomorrow morning in Cherry, by a committee from the Board of State Mine Inspectors, and the investigation commission appointed by the Governor at the last session of the legislature. As you know, that commission is composed of three representatives from the Operators' Association of Illinois, three representatives from the Miners' Union, and three disinterested persons. The act of the legislature creating the commission gives it authority to examine into the condition of mining in the State of Illinois, with a view of drawing up a new code of laws. It had already been organized and was ready to go on with its work when the Cherry disaster took place, and naturally, therefore, its energies at once will be directed to investigating this disaster. Tomorrow morning the active work of investigation will be begun in connection with the Coroner and the Board of Mine Inspectors.

I do not think it is incumbent on me to say anything about the Cherry disaster. You have already heard a great deal about that, and it would certainly be out of place for me as a member of the Commission, to make any comments upon it before an investigation has been made.

As Mr. Abbott has already reminded you, it was due to the efforts of this Society and other societies in the state that there has been

established at the University of Illinois a department of Mining Engineering. That department is now in operation, and a course has been laid out adapted as nearly as possible to the needs of this state. Our appropriation was not so large as we hope it will be in the future; consequently it will not be advisable nor practicable at first, to go into all the various branches of mining engineering; that we shall hope to do at some future time. In starting we shall therefore devote our energies especially to the needs of Illinois. A circular has been prepared and will be distributed in the next few days, descriptive of just what the course will be.

In that connection, I want to add just a word upon the subject of secondary education, in connection with mining. When you consider that each year the output of coal in this country is increasing approximately ten per cent; what does that mean? It means at least 70,000 new workmen must be brought into the industry each year, and the greater number of these workmen come to us untrained, absolutely unacquainted with mining, and usually from the farming districts in southeastern Europe. The training of these men is a problem in education that has not yet been solved, and it is one that is exercising the minds of all those who are thinking about the subject of education. Just how that is going to be gotten at we do not know, but the University stands ready to help by means of lectures or in any other way that it possibly can, any association throughout the state that is aiming to help, not only these men who are at the face—the foreign men, many of whom can not speak English—but also the many who are preparing themselves for the position of mine manager or mine examiner.

In connection with the work Mr. Williams has spoken of, if the men will come to Urbana for training in connection with the helmet work, we hope also to give other lectures in connection with the technology of mining that will be of assistance to them. We are always open to suggestions, and shall be only too glad to receive them at any time.

Mr. Moore: I would like to ask one question in connection with the coal-dust. Does the sulphur in the coal play any particular part in forming the combination that we have in gunpowder? Gunpowder, as I understand it, is composed largely of powdered charcoal and sulphur, with nitrate of potash. Is it possible that there is an absorption of excess of oxygen by the damp dust, and are those causes of dust explosions?

Mr. Rice: The subject is complex, of course, but I hardly think that sulphur can play an important part, from the fact that as violent explosions, or perhaps more violent, occur with the dust that comes from Pocahontas coal, which carries, in some of the samples that have been submitted to us, less than one per cent sulphur, as contrasted with other coals carrying three to four per cent. We do not find, from the informal observations made, that

there is any material difference in the violence of our experiments, when we use the high sulphur coal. We must bear in mind that the sulphur of coal is already in combination, either as sulphide of iron or sulphate of lime—not free sulphur as is black powder.

Mr. H. B. Gear, M.W.S.E: My observations are purely those of a layman who had never been in a mine prior to November 22d, of this year. During that week it was my privilege to make a tour of a number of mines in various parts of Illinois, in company with three mining experts and an operating engineer, for the purpose of making recommendations as to the safeguards which might be provided to prevent the occurrence of a disaster. These mines varied widely in size and equipment and are probably quite representative of general conditions throughout the Illinois coal fields.

As an electrical inspector it was my special duty to make suggestions as to the electrical equipment. The construction which is commonly used about these mines and which I am told is standard for Illinois mine work, is carried out with scarcely a vestige of recognition of the requirements of the Fire Underwriters for the wiring of buildings. The use of bare wire is common, and in many cases the only insulation is that afforded by the wooden timbers on which the bare wire is fastened by staples or spikes. Lighting circuits are sometimes connected to heavy feed wires without any protective fuses, and the soldering of joints is considered an unnecessary refinement.

Such construction offers every opportunity for the inception of a bad fire, in case of accidental crosses or grounds, and violates the fundamental principles upon which the rules of the National Board of Fire Underwriters are based.

It was explained that all such construction must be executed by members of the miner's union, and as there are no skilled electricians among them, the work cannot be done as it should be.

A suitable code of rules should be embodied in a statute requiring such construction to be made safe, and providing for its enforcement by state inspectors.

One very useful application of electricity seems to have been neglected in general mine practise, viz: the telephone. It would appear that an intercommunicating telephone system connecting to the hoisting engineers, cagers, superintendent's office, and other important points about the mine would serve a very useful purpose during the daily operation of the mine, as well as being an invaluable means of quick communication in emergencies.

The practise of lighting the entries and escape roads by electric light which prevails in some of the larger mines should be made universal, and should be extended to all principal entries, escape roads and escape shafts. This is especially important in stables and store rooms where oil and inflammable materials are kept. This would permit the enforcement of a rule forbidding the use of oil lamps in such places.

Careful attention was given to the general fire risk in the mines visited and to the provision of means of access to the escape shaft from any part of the mine in case of fire near the hoisting shaft. Judging from the conditions found, I can heartily endorse the conclusions drawn by Mr. Rice at the close of his paper.

There can be no question as to the necessity of providing construction which is as near fire proof as possible, and ample means for the fighting of fire and for the escape of men.

Mr. Earnest F. Smith, M.W.S.E. (by letter): It is my opinion that the most serious element of danger present in Illinois mines results from the general practice of maintaining the stables at the bottom. This extraordinary hazard should be eliminated by a statute prohibiting the practice and requiring that all stables, hay rooms, etc., be installed at the top. However, much can be done to reduce the risk, pending such action. The stable and hay room should be of fire-proof construction throughout, and should be provided with air-tight, fire-proof doors to insure the confining of fire which might originate in the inflammable hay and bedding contained therein. Such stables and hay rooms should also be thoroughly equipped with an automatic sprinkler system. The practice of using open flames in and about these rooms should be strictly prohibited, and the installation of a safe and reliable electric lighting system, constructed in accordance with specifications contained in the Underwriters' rules, should be required by law.

In all cases where escape roads lead through or past the entrances to stables or hay rooms, such roads should be abandoned for such purpose and new roads should be provided, so as to eliminate the necessity of passing through or near the stables when attempting to escape from the mine either by way of the main shaft or the escape shaft.

The main and escape shafts should be cement lined, and should not embody in their structures combustible materials of any kind. The bottom should be of fire-proof construction within a radius of fifty feet of each shaft. All wooden tipples and fan houses should be replaced with fire-proof structures.

It is questionable whether many of the mines have an adequate source of water supply for effective fire-fighting. A determined effort to obtain such water supply within limits of reasonable cost should be made, and in the event of failure, extraordinary precautionary measures should be required. Adequate pumping equipment and an extensive system of fire lines, with hose connection and hose throughout the mines, top and bottom, should be required in all mines.

A fire fighting force should be organized among the more permanent employes, and frequent fire drills should be instituted to insure efficient action during emergencies.

A local telephone system should be installed at each mine. Telephones, provided with loud ringing gongs, installed at the bot-

tom of the shafts, at all main partings, in the stables, in the fan house, the office and other upper structures. These would serve as fire alarm and as a means of promptly communicating a general alarm throughout the mine in case of disaster, actual or impending. Such a system would be an invaluable aid, during an emergency, in formulating course of procedure and transmitting necessary orders to put it into effect. In this connection it is important that general rules governing the action to be taken in various contingencies most likely to occur in the operation of a mine, be formulated and promulgated in each mine. In preparing the rules, each responsible employee in the organization should participate by contributing his suggestions and recommendations; thus all would have seriously considered, in advance, the various aspects of each contingent situation, and would be better qualified to act promptly and effectively during any probable emergency than would otherwise be the case. He would not only have considered all of the possibilities associated with various kinds of emergencies, but through the establishment of the rules would have become familiar with the best course of procedure to be followed, as written in the rules, and as representing the best combined judgment of those in authority; such judgment having been formed deliberately and under the most favorable conditions at a time when no stress or contingency confronted them.

In preparing the rules particular attention should be given to the proper operation of the ventilating system, as an error of judgment, or irresponsible action, resulting from poor discipline, affecting the handling of the fans in an emergency, would undoubtedly contribute largely to the disaster.

A high standard of discipline is essential to safety of life and property, and there is evidently room for marked improvement in most mines.

Various regulations of the miners' union and the consequent relations between the operators and the miners, in the practical operation of a mine, are seriously detrimental to the establishment and maintenance of a high order of discipline. This is a very complex subject, which is of sufficient importance to warrant thorough investigation and consideration with a view to eventually improving conditions.

In this paper, the author has made it very clear that the use of certain explosives in mining operations greatly increases the danger, and it is gratifying to learn that the U. S. Geological Survey is accomplishing substantial results in pointing the way to the miners to avoid such dangers. However, it does not appear that the Illinois mines have taken advantage of the results of these investigations, and it is evident that same should be made compulsory.

The present practice of allowing shooting to be done, under specified conditions, by others than regular shot firers, should be

discontinued, as it is very dangerous. "Windy shots" are more likely to occur under such circumstances, and disastrous explosions are often the result of careless or unskillful shooting.

In order to further reduce the explosion hazard, we should bear in mind the results of the experiments of the U. S. Geological Survey on the explosibility of coal dust. It has been stated that such dust is an element of danger, even though it be comparatively wet and composed of particles, I believe, as large as $\frac{1}{8}$ in. diameter. It is, therefore, important to prevent the accumulation of coal dust in the mine. Ample ventilation is, of course, necessary to prevent the accumulation of explosive mixtures of gas and air, and it thus becomes important to keep all air courses clear of all falls and other obstructions. This is especially so when such air courses are to be used in emergencies as escape roads. All escape roads should be lighted at all times by electric lamps, as open flames are likely to be extinguished by the strong ventilating air currents, thus seriously interfering with or possibly preventing escape in case of trouble.

I am very favorably impressed with the plan of providing accessible fire-proof, gas-tight refuge rooms in the mines, communicating with the outer world by means of a small pipe, provided in advance, through which all of the necessities of life could be supplied until such time as the imprisoned men could be rescued.

A UNIQUE TYPE OF REINFORCED CONCRETE CONSTRUCTION

THEODORE L. CONDRON, M.W.S.E.

Read December 15, 1909.

The most common material used in floor construction for buildings is wood and the usual form of wooden floor construction consists of plank flooring supported on joists, and the latter in turn supported by wooden girders between columns or walls. With the introduction of structural iron and steel, wooden columns, girders, and joists have been frequently replaced with iron or steel.

It will be noticed that except for the continuity of the plank flooring, there is no continuity in any of the parts of this construction, except that a little may be gained by riveting or bolting together the webs of iron or steel beams, as it is not practical to splice the beam flanges, over supports.

In special cases plank flooring has been replaced by brick, tile, or concrete arches sprung between steel beams, the latter being carried by steel girders.



Fig. 1.—“First Type.” Reinforced Concrete Slabs on Steel Beams.

With the introduction of reinforced concrete as a building material, the familiar forms of floor construction were very naturally reproduced in this material. The gradual development of this construction may be outlined in seven types, thus:

- (1.) Reinforced concrete slabs, carried by steel joists, and girders. Fig. 1.*
- (2.) Reinforced concrete slabs and joists, carried by steel girders. Fig. 2.*
- (3.) Reinforced concrete long span slabs, carried by steel girders. Fig. 3.*
- (4.) Reinforced concrete slabs, joists and girders. Fig. 4.*

*Brief descriptions of the illustrations of these five types are given in the appendix to this paper.

- (5.) Reinforced concrete long span slabs and girders. Fig. 5.*
- (6.) Reinforced concrete slabs, without beams or girders. Fig. 6.
- (7.) Reinforced concrete *paneled slabs*, without beams or girders. Fig. 7.

In the summer of 1907, the writer's partner, Mr. F. F. Sinks, designed and made complete sketches for a new type of reinforced concrete floor construction, eliminating the usual girders and beams.** After very carefully analyzing the stresses in this design we decided to make tests to demonstrate the correctness of our analysis. We, therefore, had a model made to one-eighth size of a

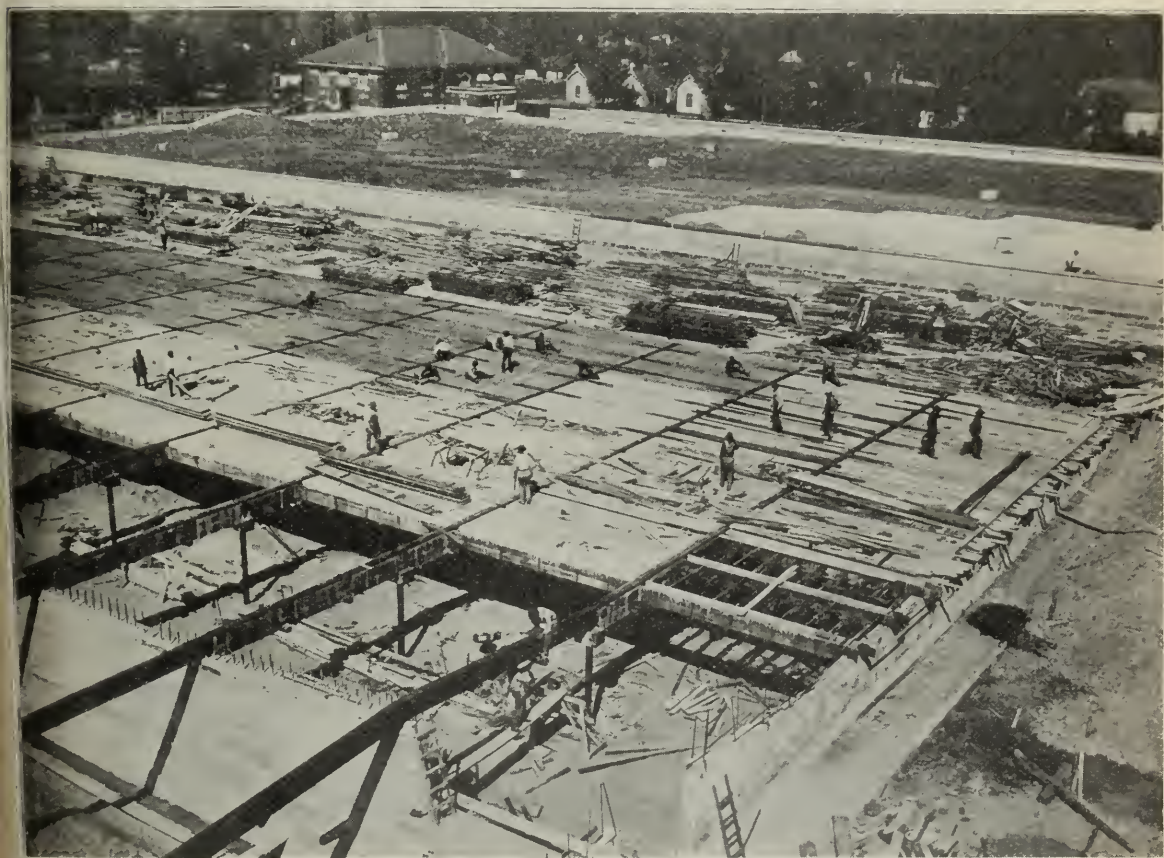


Fig. 2.—“Second Type.” Reinforced Concrete Joists and Slabs on Steel Girders. Filter Bed Roofs, Indianapolis, Ind.

portion of the first floor of the Manufacturers' Furniture Exchange Building, Fig. 5, reproducing $2\frac{1}{4}$ panels in width by $2\frac{1}{4}$ panels in length of the floor construction and columns. Another model was also made of the same proportion and with the same column spacing but following the girderless slab design referred to. These two models are shown in Fig. 8, as they were set up for testing. The surface area of these models was approximately twenty square feet

**Mr. Sinks has applied for letters patent, covering the construction here described.



Fig. 3.—“Third Type.” Reinforced Concrete Long Span Slabs on Steel Girders. Chicago City Railway Car Barns.

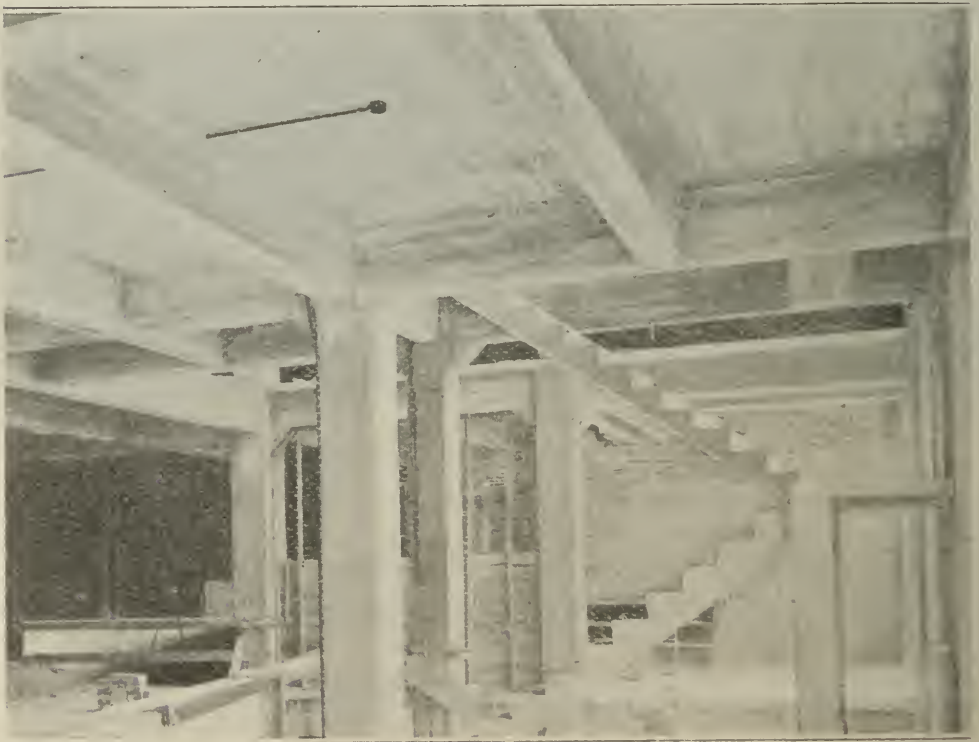


Fig. 4.—“Fourth Type.” Reinforced Concrete Girders, Beams and Slabs. Advance Thresher Co. Building.

each. A very simple apparatus was arranged for testing by hydrostatic pressure, the models being supported on heavy steel I beams and a testing platform covering the upper surface. Between the testing platform and surface of the model there was introduced a



Fig. 5.—“Fifth Type.” Reinforced Concrete Girders and Long Span Slabs. Manufacturers' Furniture Exchange Building.



Fig. 6.—“Sixth Type.” Reinforced Concrete Flat Slab. Hirsh, Stein & Co. Building.

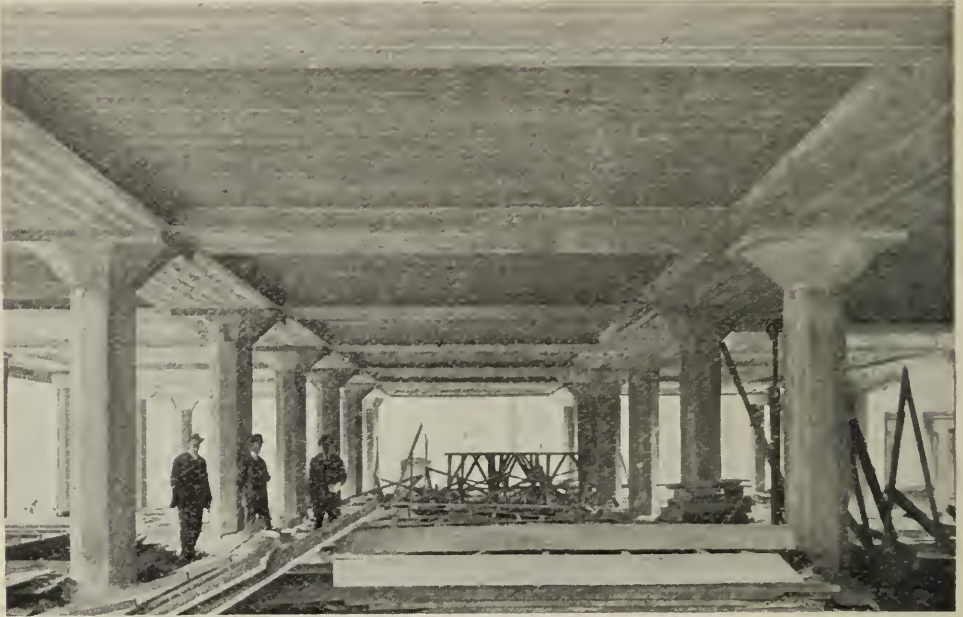


Fig. 7.—“Seventh Type.” Reinforced Concrete Paneled Slab. Studebaker Automobile Building.

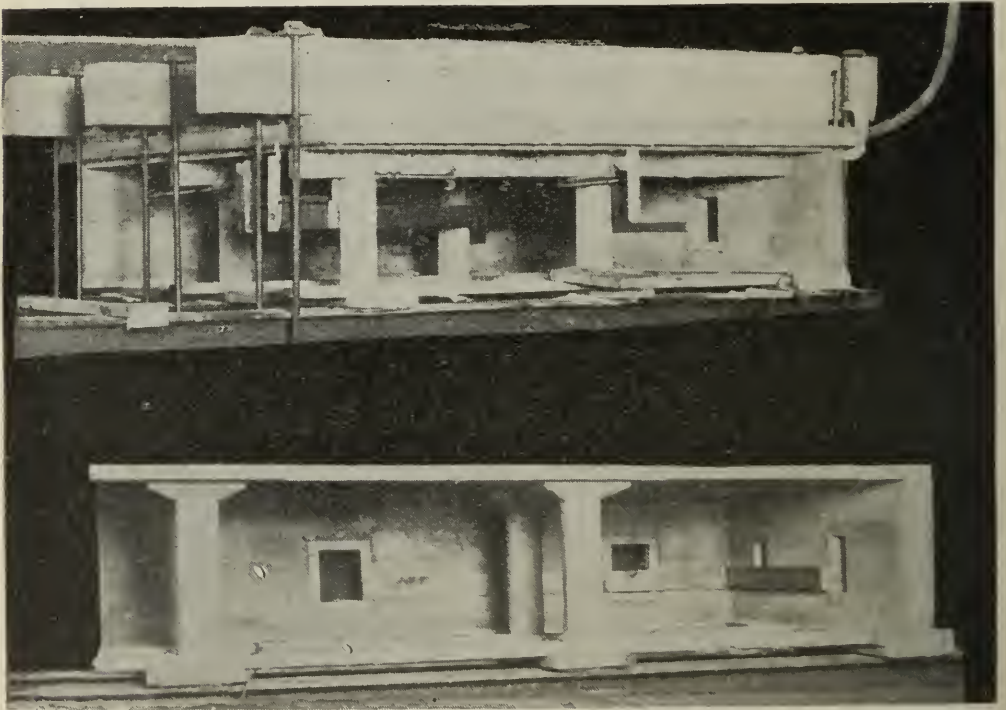


Fig. 8.—Reinforced Concrete Models, One-Eighth Full Size. Made for Tests. Upper Photograph, Model “A” Girder and Slab Type. Showing Testing Apparatus Attached. Lower Photograph, Model “B” Flat Slab Type.

rubber diaphragm filled with water and connected with a stand pipe. By raising and lowering the head of the water in the stand pipe, loads were put upon the model, varying from 0 to 970 lb. per sq. ft. Deflectometers were used to measure the deflection of each of the four panels, by means of which it was possible to measure without difficulty the deflection to a thousandth of an inch. The deflections

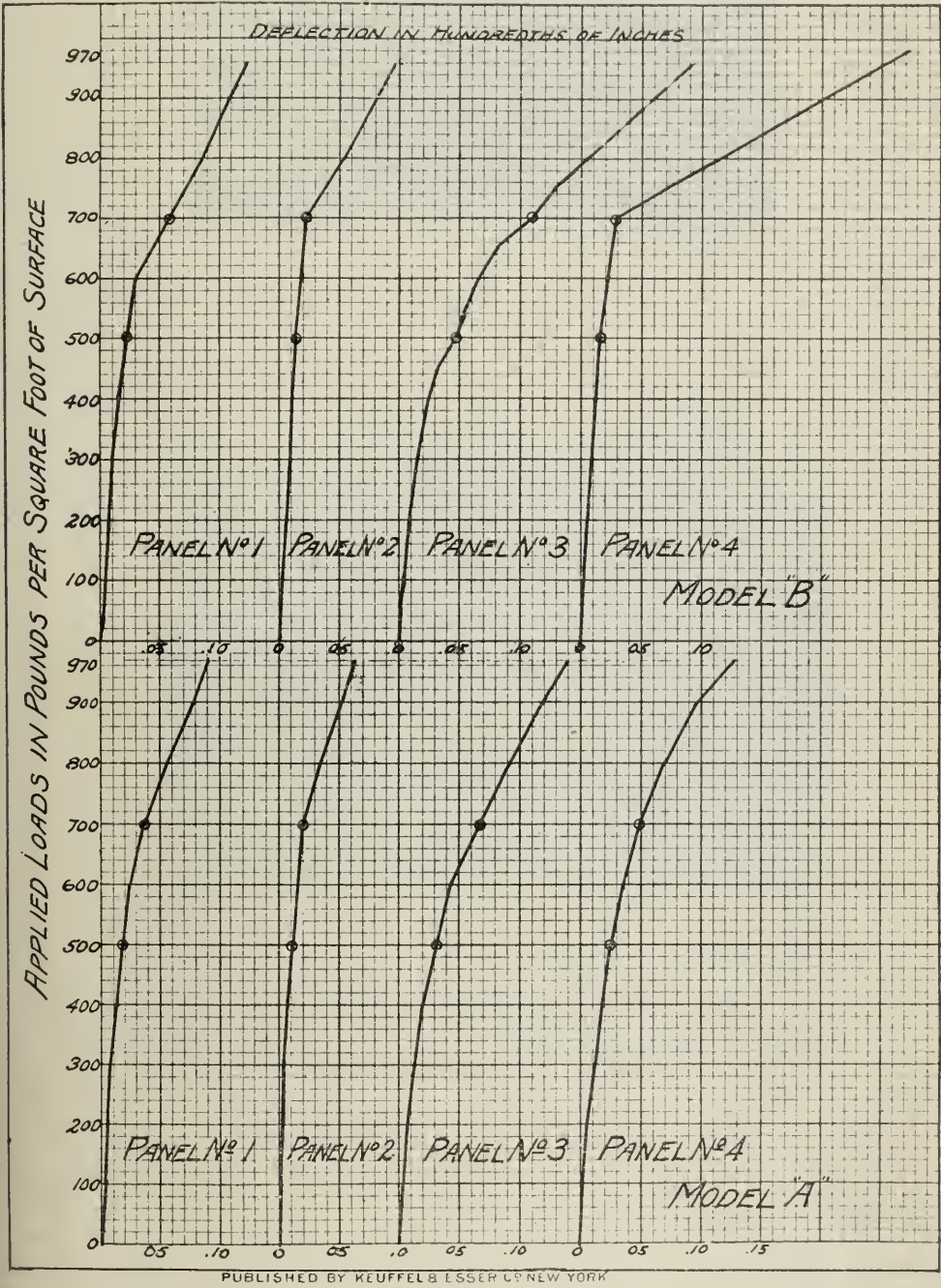


Fig. 9.—Diagram of the Deflections of the Models "A" and "B" Under Test Loads.

of these panels were recorded and these records are shown in Fig. 9. The models reproduced construction designed for safe loads of 150 lb. per sq. ft. The dead weight of the floor, in full size, averaged about 85 lb. per sq. ft., hence, the dead load and "safe live load" together equaled 235 lb. per sq. ft. With a factor of safety of three,

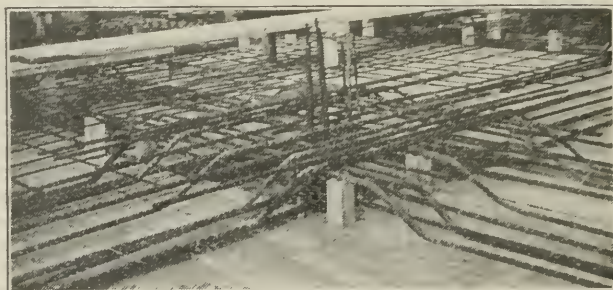


Fig. 10.—Part of the Floor Reinforcement of Flat Slab Type. Hirsh, Stein & Co. Building.

the theoretical ultimate strength of the construction would, therefore, be 705 lb. per sq. ft. In models of this kind, the carrying capacity of the models should be the same as the carrying capacity of the floor construction, that is, the model although of one-eighth the size should be capable of carrying as much load per square foot as the

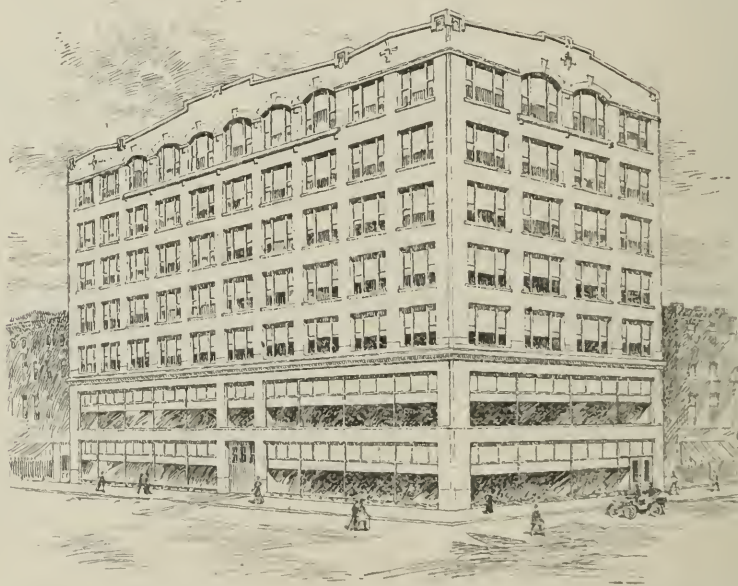


Fig. 11.—Architect's Perspective Sketch of Studebaker Automobile Building.

actual floor and not one-eighth of the load. It is, therefore, interesting to note from the deflection diagrams, that while these models carry, with only a few cracks and no sign of collapsing, as much load as we could put on with our apparatus, namely 970 lb. per

sq. ft., they show marked changes in the deflection curves after the loads exceed 700 lb. per sq. ft. The study of the tests of these models has been of great assistance in determining the proper method of analysis of the stresses in this construction and also confirmed us in the correctness of our original analysis.

This design comes under the "6th" type, the floor "slab without girders or beams." The first practical application made of this design was in the reinforced concrete construction of a factory building for Hirsh, Stein & Co., at Hammond, Ind., shown in Fig. 6. These floors were designed for a safe working load of 400 lb. per sq. ft. in addition to the dead load. The columns are 15 ft. apart. As the building is used for the manufacture and storage of fertilizer, there was no attempt to make it ornamental. The partial reinforcing of the floors, shown in Fig. 10 indicates the important elements of the design, but these will be made clearer in the illustrations and descriptions of the Studebaker Building, which follows. It should be stated, however, that these floors are carrying daily the full 400 lb. live load for which they were designed, and probably this is frequently exceeded. This load is equivalent to the weight of

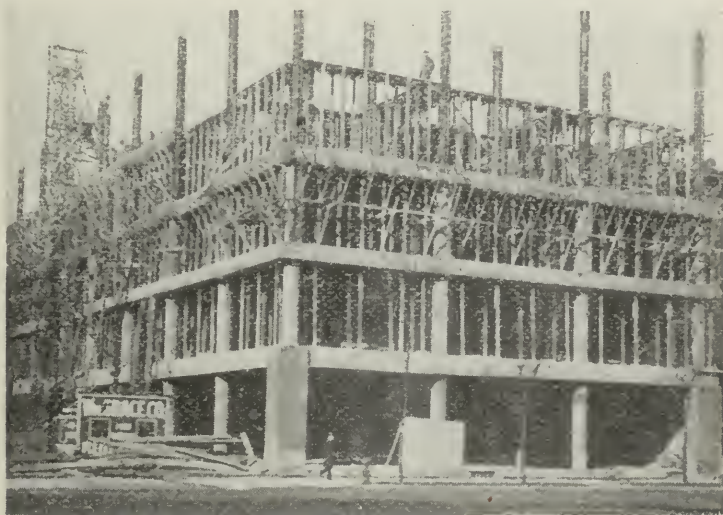


Fig. 12.—The Studebaker Automobile Building Under Construction.

water covering the floor seven feet deep. The photograph, Fig. 6, was taken by the writer when they were beginning to use the floor by piling fertilizer from a belt conveyor.

This brings us to the seventh type of construction, "the *paneled slab* without girders or beams," a type especially suited to business and factory building and adopted for the construction of the Studebaker Building now going up at the corner of Michigan Ave. and 21st St., Chicago.

This building is being erected by Wm. Grace & Co. for the owner, Mr. D. M. Cummings, and is to be occupied by the Studebaker Bros. Mfg. Co. for the sale, storage, and repair of automobiles. The Standard Concrete Construction Co. are sub-contractors for the

concrete work. The reinforced concrete portions of this building were designed by the writer's firm as consulting engineers for the architect, Mr. William Ernest Walker, of Chicago. The appearance of the exterior when finished will be as shown in Fig. 11, which is reproduced from the architect's perspective drawing. The building is seven stories high above the sidewalk with a basement 8 ft. 6 in. clear under the ceiling, as shown in Fig. 15. The foundations are concrete caissons carried to bed rock 90 ft. below grade. The first and second stories have practically uninterrupted show windows on the two street frontages while the stories above the second have brick curtain walls trimmed with stone, and broken by groups of large windows. The reinforced concrete wall girders are faced with brick so that no concrete appears on the exterior.

The eighth floor forms a temporary roof, provision having been made for continuing the building several stories higher in the future if so desired. A photograph taken on Nov. 4th, Fig. 12, shows the columns, floors, walls and girders completed for four stories and work progressing on the fifth floor.

Typical interior views are shown in Fig. 13 and Fig. 14, being photographs of the basement, and first story, taken just after the forms were removed from under the ceilings. The column spacing, it will be noted, is unusually great, being practically 24 feet, each way, making the diagonal distance between column centers about 34 feet.

The advantages gained by this paneled slab design are:

(1.) *An improved form of construction whereby great strength and carrying capacity are attained with an economical expenditure for material and labor.*

(2.) *A construction in which the stresses due to dead weight and all applied loads can be accurately determined.*

(3.) *A minimum depth of floor and a consequent reduction in the height of the building.*

(4.) *An improvement of the illumination of the rooms by the elimination of dark ceiling shadows; and*

(5.) *A reduction in the expense of installing a sprinkler system.*

The construction consists of continuous and paneled slabs, supported upon flaring column heads. A cross section of the adopted design of this building and also a typical partial section of a design for the same building, using reinforced concrete girders, beams, and slabs is shown in Fig. 15. The same clear story heights have been provided in both designs. It will be seen that the excavation for the basement is 1 ft. 6 in. less for the adopted design than for the other and that the height from the sidewalk to the surface of the eighth floor is 93 ft. 8 in. as compared with 104 ft. 2 in. or 10 ft. 6 in. less for the adopted design than for the other. A typical floor plan of the building, Fig. 16, shows the arrangement of the columns,

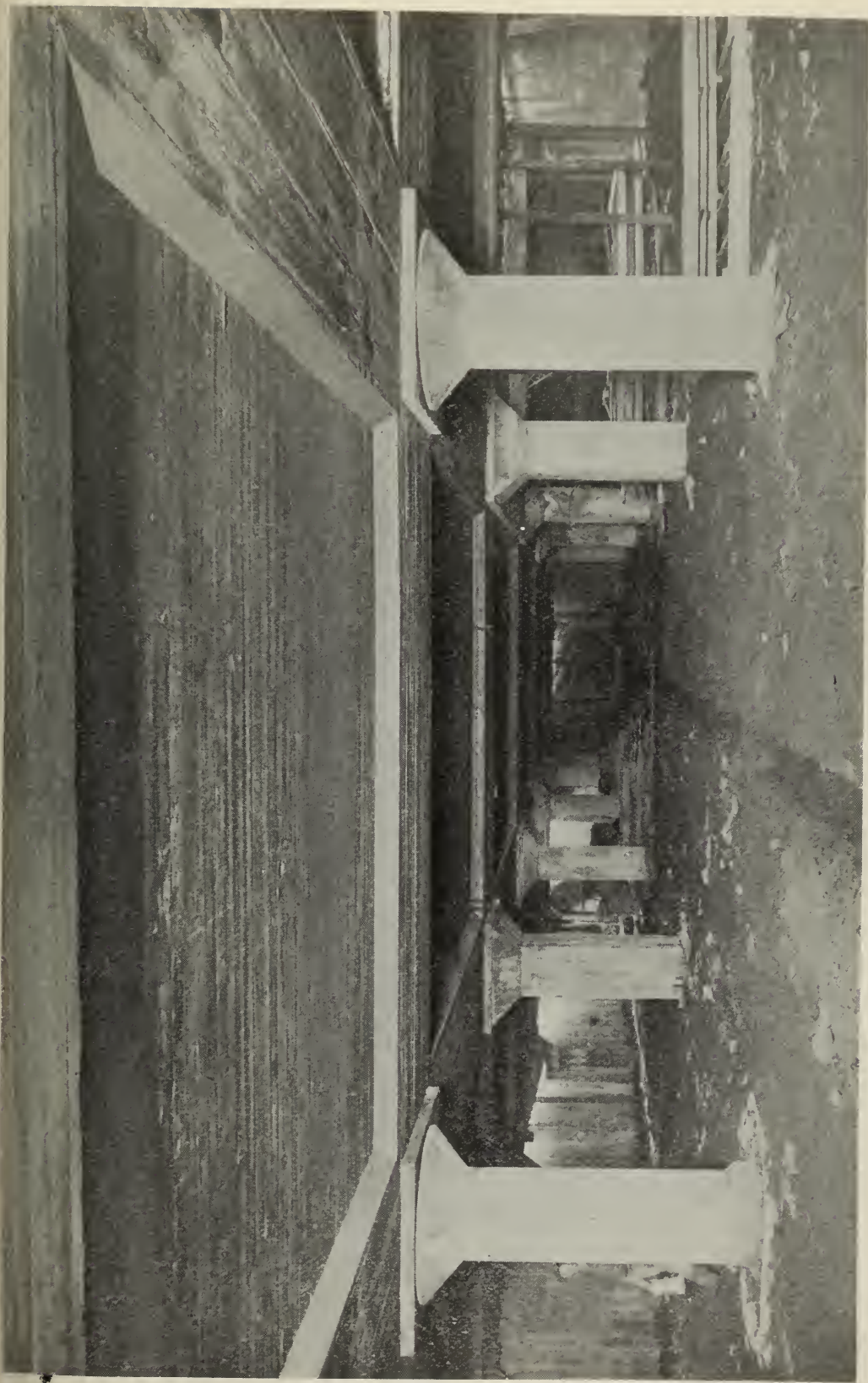


Fig. 13—The basement of the Studebaker Building, just after the forms were removed from under the first floor. Clear height to be 8 feet 6 inches. The columns are spaced 24 feet apart and carry loads of about 1,000,000 lbs. each. They are supported by concrete caissons sunk to bed rock 90 feet below the sidewalk grade.

stairs, and elevator openings. In the illustrations, it will be noted the adopted design has columns with widely flaring heads or capitals surmounted by square caps. These column heads and caps, support and form a part of a platform or slab, which may either be of uniform thickness or may be paneled, as in this case, to reduce the thickness in the center, but for purposes of calculation and design the floor and ceiling consists of intersecting slabs, having widths equal to, or slightly greater, than the extreme width of the column caps, these intersecting slabs in turn supporting enclosed slabs. In this construction, whether the floor is made of uniform thickness or is made thinner in the center, the manner of reinforcing and supporting it is the same.

This method of reinforcing the floor construction is exceedingly simple and direct, and is clearly indicated in Fig. 17 and Fig. 18. The longitudinal reinforcement of the intersecting slabs consists of $\frac{3}{4}$ in. and $\frac{7}{8}$ in. square steel bars. These bars are bent as shown in the illustrations so as to reinforce the under side of the intersecting slabs between the column supports and to reinforce the upper face of these slabs over the column supports and for a considerable distance each side of the column in order to provide for tension due to negative moment in this region. In addition to the longitudinal reinforcement, the intersecting slabs are reinforced laterally near their upper faces, by $\frac{1}{2}$ -in. round bars which extend across the full width of the intersecting slabs and a considerable distance into the enclosed slab. This lateral reinforcement serves a double purpose:

(1.) Reinforcing the intersecting slabs against bending laterally and hence the loads from the enclosed slabs are distributed over and carried by the full width of the intersecting slabs instead of being carried by their adjacent edges only; and

(2.) Taking care of the tension in the upper face of the enclosed slab due to negative moment, thus restraining these enclosed slabs and reducing the positive moment in them.

The lower reinforcing of the enclosed slabs consists of two layers of $\frac{1}{2}$ -in. round bars placed at right angles to each other (spaced closer together in the middle portion), near the under face of the slab to fully reinforce it for tension due to positive moment. These slabs are also reinforced around their sides, near their upper faces by the $\frac{1}{2}$ -in. bars already referred to, for tension from negative moment.

An important feature of this design is the combination of the column heads with the intersecting slabs, whereby the depth and hence the strength of these slabs is greatly increased in the region of greatest negative moment, namely at the supports. Between the column heads the intersecting slabs have their upper faces supplemented by the concrete in the enclosed slabs and, therefore, they may be considered as having a wide T section, thus increasing the strength of the slab to resist the compression due to positive moment.

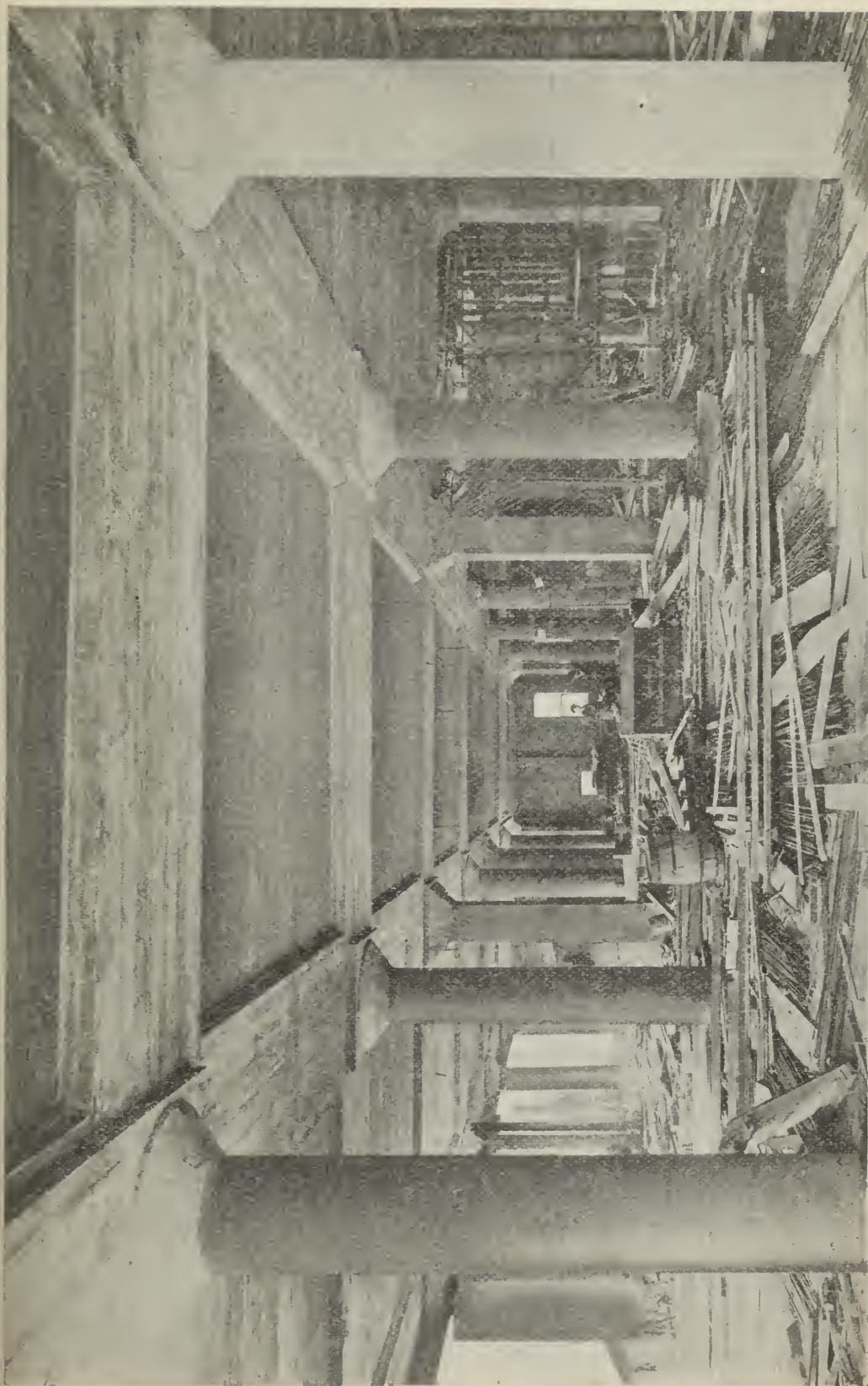


Fig. 14—First Story of the Studebaker Building, just after the forms have been removed from under the second floor. Clear height 15 feet; columns spaced 24 feet apart. The bars hanging from the ceiling on the right are part of the reinforcing for one of the stairways to be built. A partition is to be built where the square columns occur.

between the column heads. The wide column heads, of course, reduce the clear spans of the intersecting slabs.

By paneling the ceiling in its middle portion, a great saving is made in material and hence in the dead weight, over what would be necessary if the entire slab were of uniform thickness.

This construction is so designed that wherever possible it is made continuous over supports, hence the deflections and stresses are much less than is the case for non-continuous construction. It is this feature, which can be secured so easily in reinforced concrete construction, that makes it possible to greatly reduce the depth of beams and slabs where they are properly reinforced.

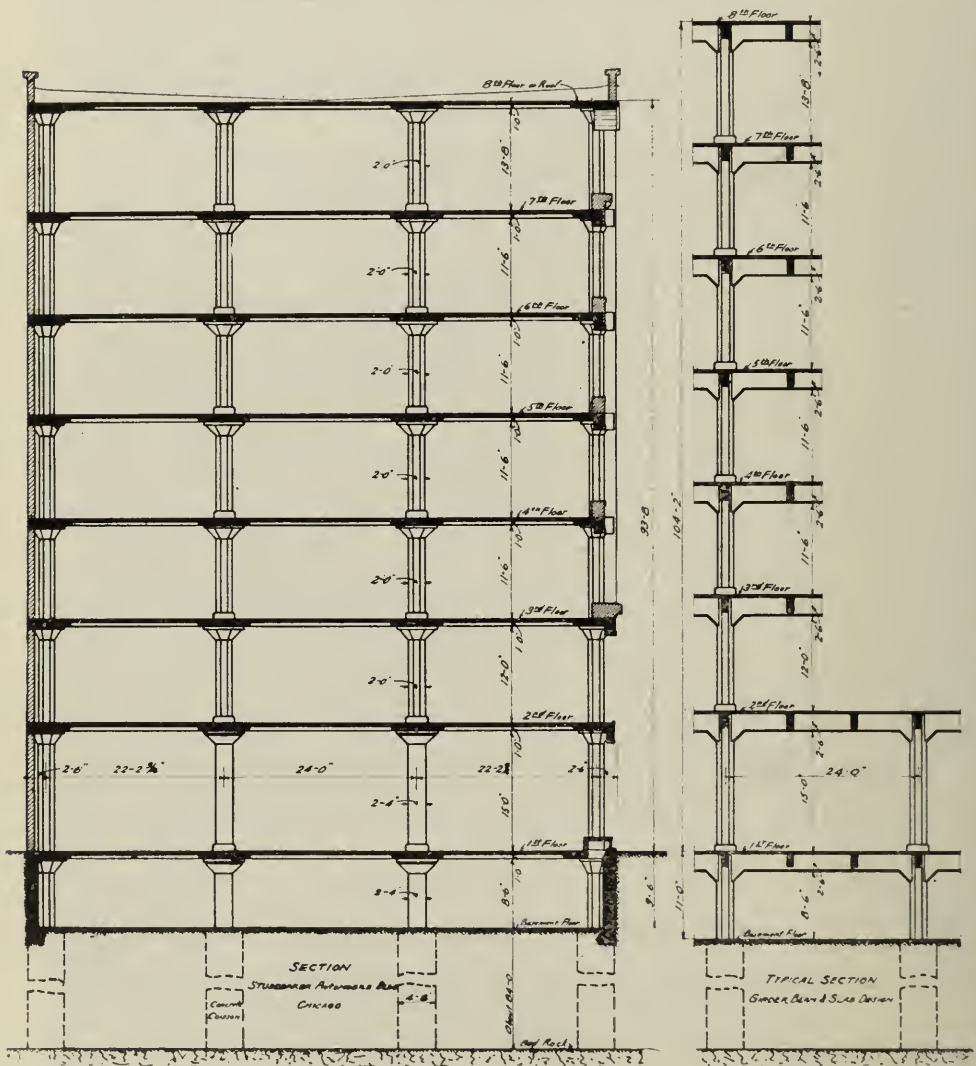
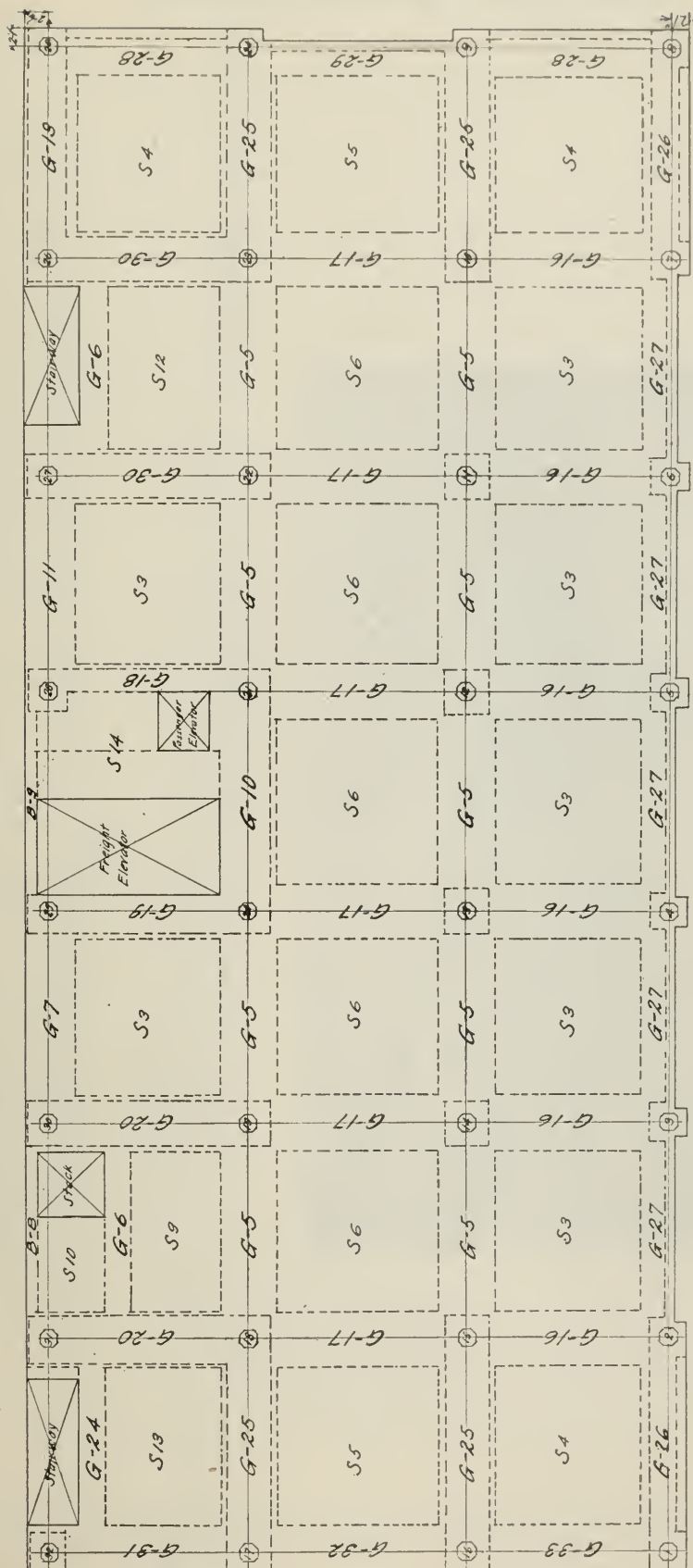


Fig. 15.—Cross-Section of the Studebaker Automobile Building, as Built, and a Partial Section of an Alternative Design for the Same; with Reinforced Concrete Girders, Beams and Slab. Showing the Saving in the Building Height of the Former, While Preserving the Same Clear Ceiling Height.



TYPICAL FLOOR FRAMING PLAN

Fig. 16.—Typical Floor Plan of the Studebaker Building.

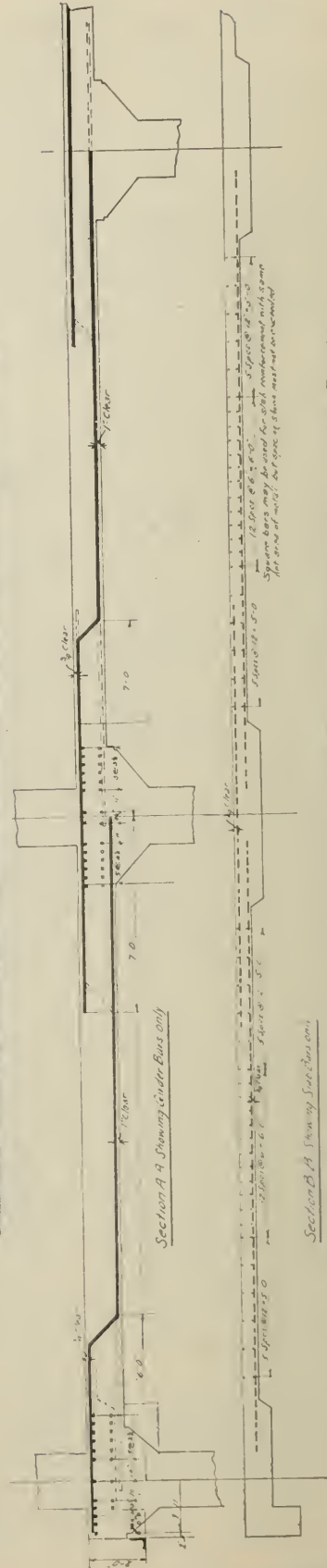
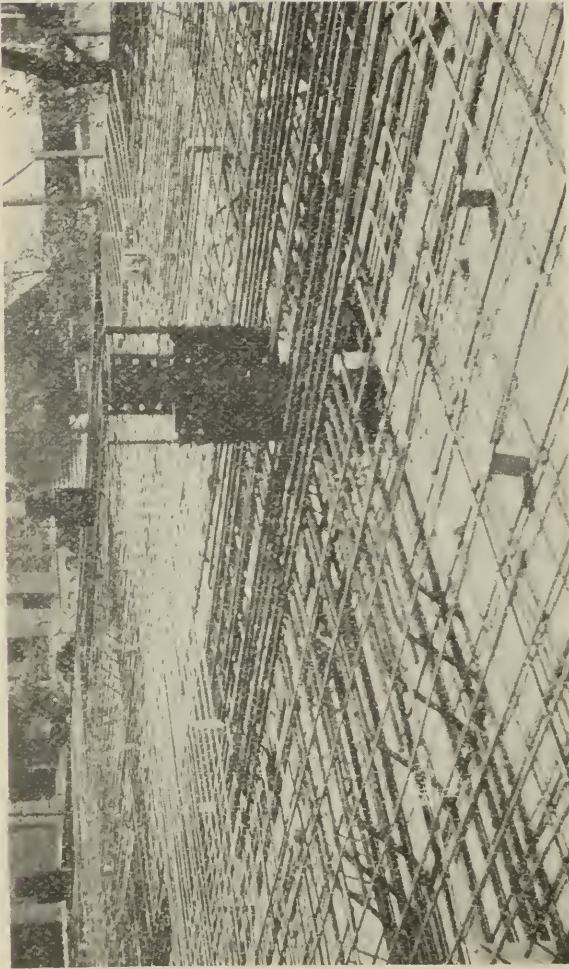


Fig. 17.—Photograph and Diagram of the Floor Reinforcement of the Studenbaker Building.

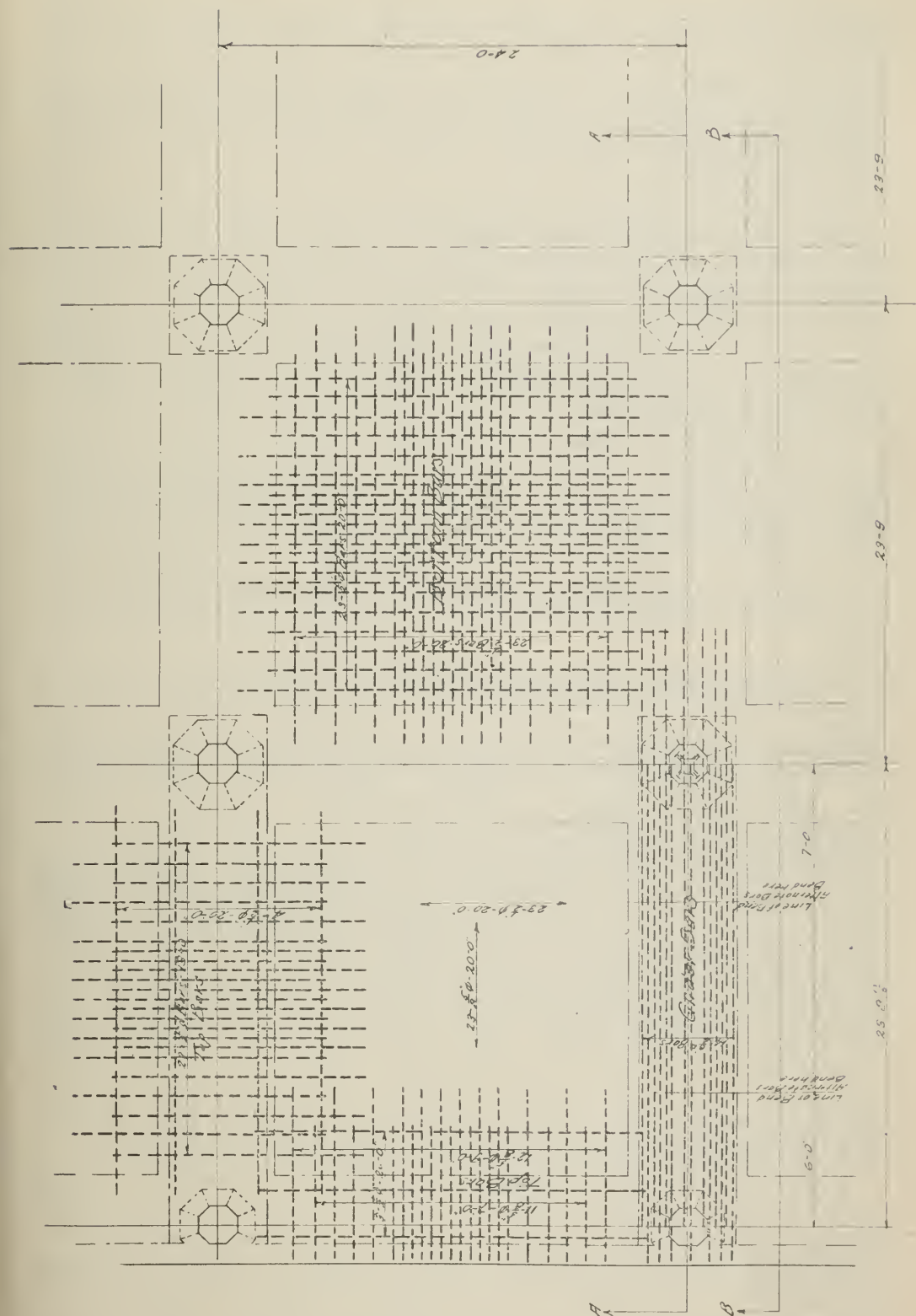


Fig. 18.—Part Floor Plan of the Studebaker Building, Showing the Arrangement of the Different Elements of the Reinforcement.

December, 1909

As will be seen by referring to the floor plan, Fig. 16, it is possible in this construction to provide openings anywhere in the enclosed slabs or to omit the enclosed slabs altogether without thereby weakening the construction in any way; or any one of the intersecting slabs may be changed in position, thus readily providing openings for elevator and stair wells, and still leave the stresses in the construction determinate.

In the girder and beam design shown on the right of Fig. 15 and in Fig. 20, a four inch slab is supported by beams spaced 8 ft. apart, which in turn are supported by girders connecting to the columns as shown. The girders are 23 in. wide by 26 in. deep under the slab, or 30 in. over all, and the beams are $11\frac{1}{2}$ in. wide by 22 in. deep under the slab, thus making the maximum depth of the floor for the typical panel 30 in. The maximum depth of the floor of the typical panel of the adopted design is but 12 in., as shown in Fig. 15 and Fig. 19.

Both of these designs were calculated for a live load of 100 lb. per sq. ft. and for the bending moments for beams and slabs and the unit working stresses for concrete and steel allowed in the proposed revised Chicago City Building Ordinance. That is, the moments

$$WL^2$$

for beams and slabs were calculated as $\frac{WL^2}{12}$ for intermediate spans, as

$$WL^2$$

$\frac{WL^2}{10}$ for end spans; the maximum allowable compression in concrete

in bending was taken at 700 lb. per sq. in. and the maximum tension in the steel at one-third of the elastic limit or 18,000 pounds per sq. in. The maximum shear or diagonal tension in concrete without reinforcement was taken at 40 lb. per sq. in.

The quantities of concrete and steel in these two designs, taking into account the extra concrete in the column heads in the adopted design, are nearly the same, in fact there is 6% less concrete and 3% more steel in the girder and beam design than in the adopted design. With the prevailing unit prices for concrete and steel the total cost of materials alone is practically the same for the adopted design and the girder and beam design. But in the cost of the formwork and of placing the steel and concrete in the two designs, there is a great saving in favor of the adopted design. The greater simplicity of the formwork required for the adopted design over the girder, beam, and slab design can be seen by comparison in Fig. 19 and Fig. 20.

The columns in the Studabaker building are of the Gray type and are built up of eight steel angles and plates, riveted together as shown in Fig. 21, and surrounded by concrete. The steel is designed to carry the full load in the lower stories, without taking into account the concrete. According to the requirements of the building ordinance referred to, structural steel columns with milled and spliced joints, when embedded in and surrounded by concrete, may be designed on

the basis of allowing a stress per sq. in. in the steel of 18000—70—

but never to exceed 16,000 lb. per sq. in. If the concrete is assumed to carry part of the load, then the stress in the steel is not to exceed 15 times the stress in the concrete. Without hooping the columns, the stress in the concrete is not to exceed 500 lb. per sq. in., and the steel 7,500 lb. per sq. in. The basement columns carry nearly 1,000,000 lb. each and have approximately 60 sq. in. of steel. The seventh story columns are designed as reinforced concrete columns. In these columns steel tees replace the angles. The fifth and sixth story columns are shown being erected in Fig. 22. This particular type of column is not essential to this construction.

The reduction in the height of buildings gained by adopting a floor and ceiling construction of this type, without beams or girders, results in effecting a saving in walls and columns; in equipment for elevator, heating, plumbing, sprinkler systems, and lighting; and in the annual expenditure for elevator operation and for heating. By the elimination of deep girders and beams, the lighting of the rooms is greatly improved and, therefore, there is a saving in the cost of illumination. These benefits are also obtained by other forms of flat ceiling construction, but two marked advantages of this construction over other designs are:

(1) That the stresses due to the weight of the structure itself, as well as loads to be carried, are determinate and therefore, designs for this construction can be made with the same assurance as to their strength that is demanded for designs of railroad bridges and similar structures.

(2) By paneling the ceiling and thus making the slab thinner in the middle, the amount of concrete and consequently the weight of the structure to be carried by the columns is greatly reduced. In the case of the Studebaker Building, the reduction in the dead weight amounts to over 3,500,000 pounds.

These several advantages are gained without sacrificing architectural appearance, for the architectural effect of this construction is pleasing, presenting a happy combination of the lines of strength and beauty.

APPENDIX.

Of the "seven types of reinforced concrete construction" outlined at the beginning of this paper, the first five are each illustrated by the following examples selected from structures designed in the writer's office.

The first of the seven types of reinforced concrete construction referred to, that is, "slabs on steel joists and beams," is illustrated by the floor construction designed for the Heath & Milligan Mfg. Co.'s building, and is shown in Fig. 1.

The second type, "reinforced concrete slabs and beams carried by steel girders," is illustrated by the construction of the reinforced

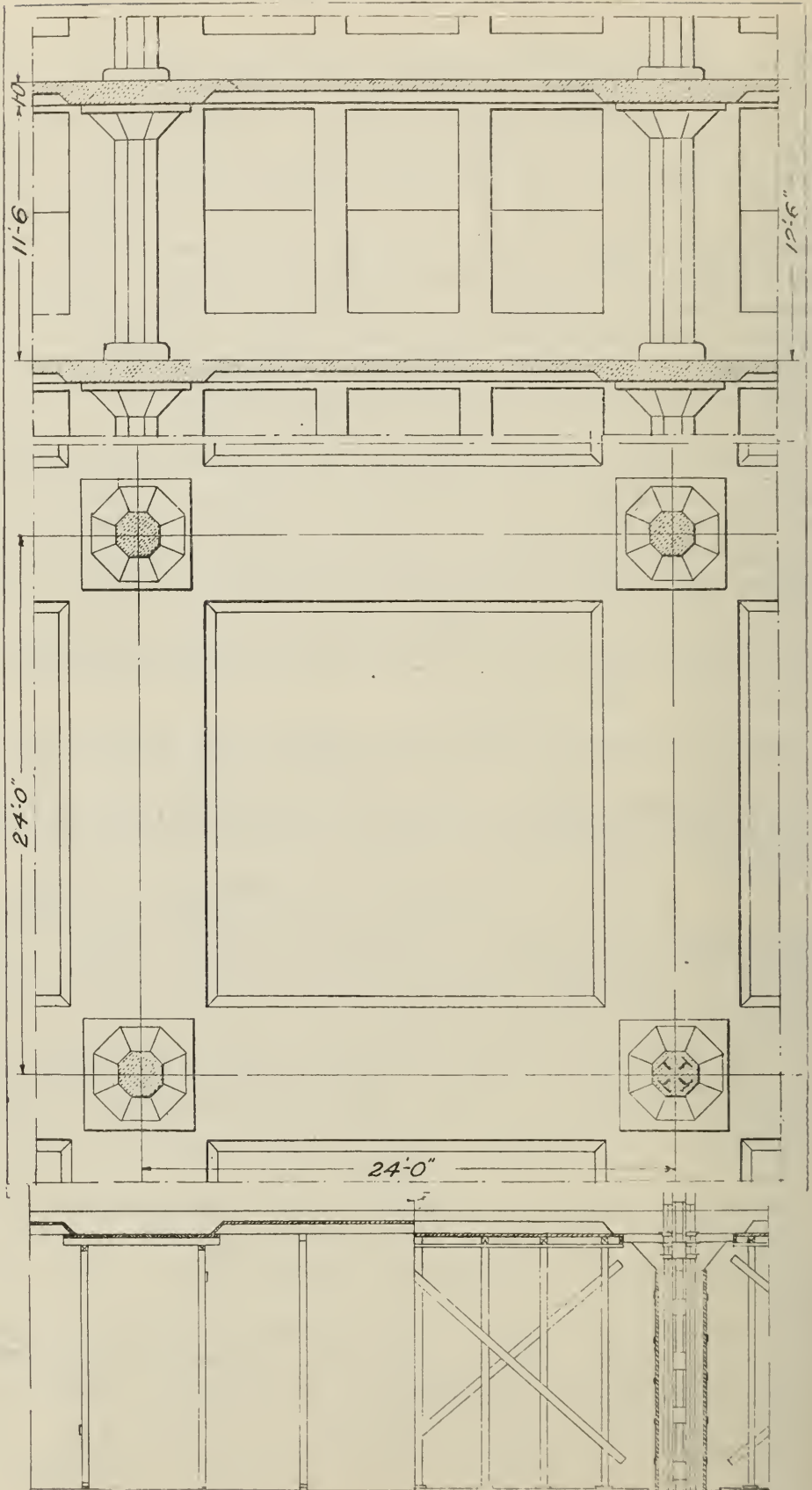


Fig. 19.—Cross-Section, Plan and Formwork for a Typical Panel of the Paneled Slab Design for the Studebaker Building, as Built.

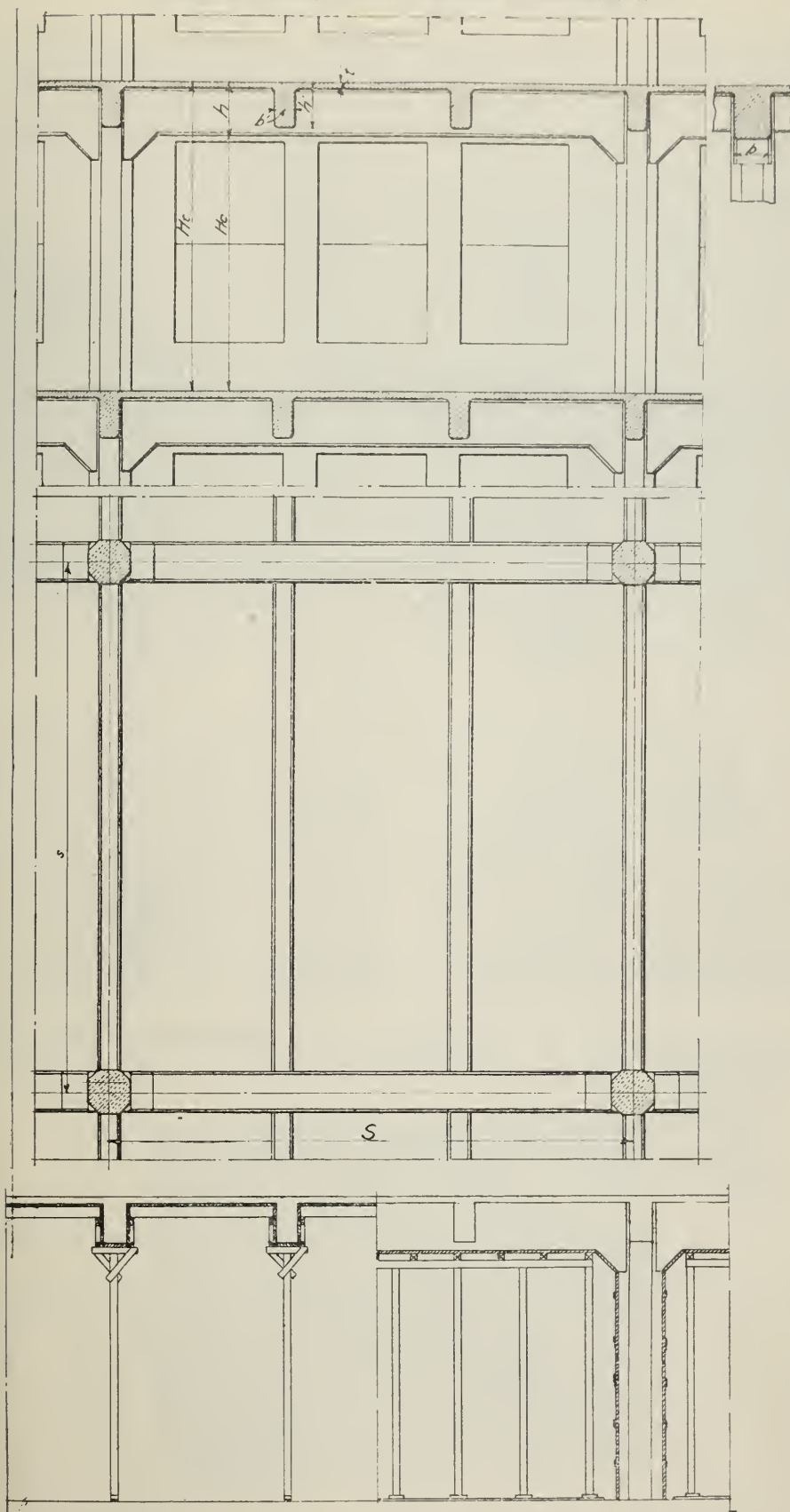


Fig. 20.—Cross-Section, Plan and Formwork for a Typical Panel of the Girder, Beam and Slab Design for the Studebaker Building (Not Built).



Fig. 22.—Erecting Steel Columns for Fifth and Sixth Stories, Studebaker Building.

ft. wide by 350 ft. long, covering approximately $1 \frac{2}{3}$ acres. No expansion joints were provided in these surfaces nor was any waterproofing used. Gravel concrete of a 1:2:4 mix was used. Each roof drains toward one end and is covered with two feet of cinders. After a heavy storm, water runs through the drains for two or three days, nevertheless the roofs do not leak. The cost was much less than that of many other reinforced concrete roofs designed for similar purposes, being under 40 cents per square foot of roof surface, including the steel girders and iron columns supporting the same.

The third type, namely, "long span slabs supported on steel girders," is illustrated by the reinforced concrete construction of



Fig. 23.—Columns, Girders and Partition Wall.
Roofs Over Filter Beds of the Indianapolis (Ind.) Water Company.

roofs designed for the Chicago City Railway Co., one of which is shown in Fig. 3, Fig. 26 and Fig. 27. In this case the roof consists of a reinforced concrete slab $4\frac{1}{2}$ in. thick spanning 16 ft. between supports, these supports being riveted steel trusses having a span of 56 ft. between walls. Later two more roofs were built with reinforced concrete girders substituted in place of the steel trusses. No



Fig. 24.—Reinforcement for Beams and Slab.

waterproof covering or waterproofing compound was used but the reinforcement is so placed, as to take care of all tension stresses due to loads and to temperature changes, hence, no cracks have developed which let water through. Over twenty acres of these roofs are now in service and giving excellent results. The roof shown is over 500 ft. long and nearly 400 ft. wide, covering over four acres and is built without expansion joints in its surface. This is also true of the other three. Our success with the Indianapolis roofs, led us to design the first two of these roofs for the Chicago City Railway Co. In the two later roofs, some modifications were made in the arrangement of the reinforcing bars, especially in that some of the bars in the upper face were made to run the entire length of the



Fig. 25.—Interior After Completion.

panels instead of extending only a quarter of the panel length each side of the supports.

Where the length of a span is so great that a slab of sufficient strength to carry the load becomes too heavy, it has usually been found better to use subdivided panels, with reinforced concrete beams and girders as well as slabs. This is the "fourth type" referred to and is illustrated in the reinforced concrete construction designed for the Advanced Thresher Co.'s Building at Kansas City, Mo., shown in Fig. 4 and Fig. 28. In this building the girders



Fig. 26.—Reinforcement in Place on Car Barn Roof, Chicago City Railway Company.

have a span of 24 ft. between columns while the beams have a span of 18 ft. between girders and the floor slab a span of 8 ft. between beams. The floor slab is 4 in. thick, the beams are 21 in. deep below the slab and the girders 27 in. deep below the slab, therefore, the total depth of the floor is 2 ft. 7 in. These floors were designed for a live load of 250 lb. per sq. ft. and are subjected to heavy concentrated loads from traction engines carried in stock.

A typical example of the "fifth type" of reinforced concrete building construction, in which the floor consists of slabs, supported by girders running in one direction only, is illustrated in the reinforced

concrete construction designed for the eight story Manufacturers' Furniture Exchange Building in this city, shown in Fig. 5, Fig. 29 and Fig. 30. In this building the slabs have a span of 14 ft. between girders and the girders have a span of approximately 18 ft. between the columns. The construction is clearly indicated by the drawing, the slabs exclusive of the top finish being $5\frac{1}{2}$ in. thick for the first floor and $4\frac{1}{2}$ in. thick for the remaining floors. The girders being 1 ft. 5 in. deep for the first floor and 1 ft. 1 in. deep

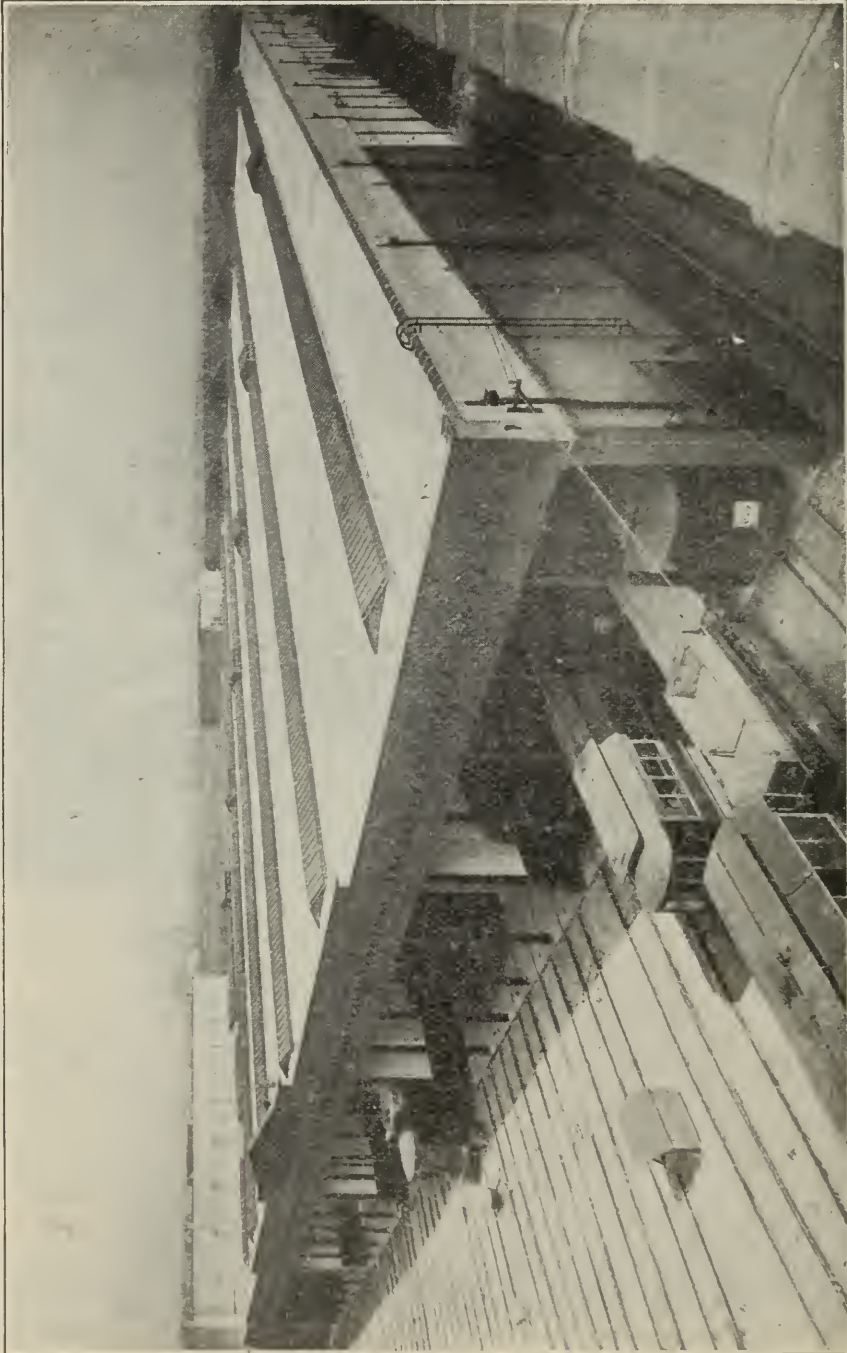


Fig. 27.—Reinforced Concrete Roof of the Car Barn at 77th Street and Vincennes Road, Chicago City Railway Company. Area Approximately 4 Acres.

for the remaining floors, measured under the slabs, making the total thickness of these floors, including the top finish 1 ft. 11¼ in. for the first floor and 1 ft. 6¼ in. for the other floors. The columns

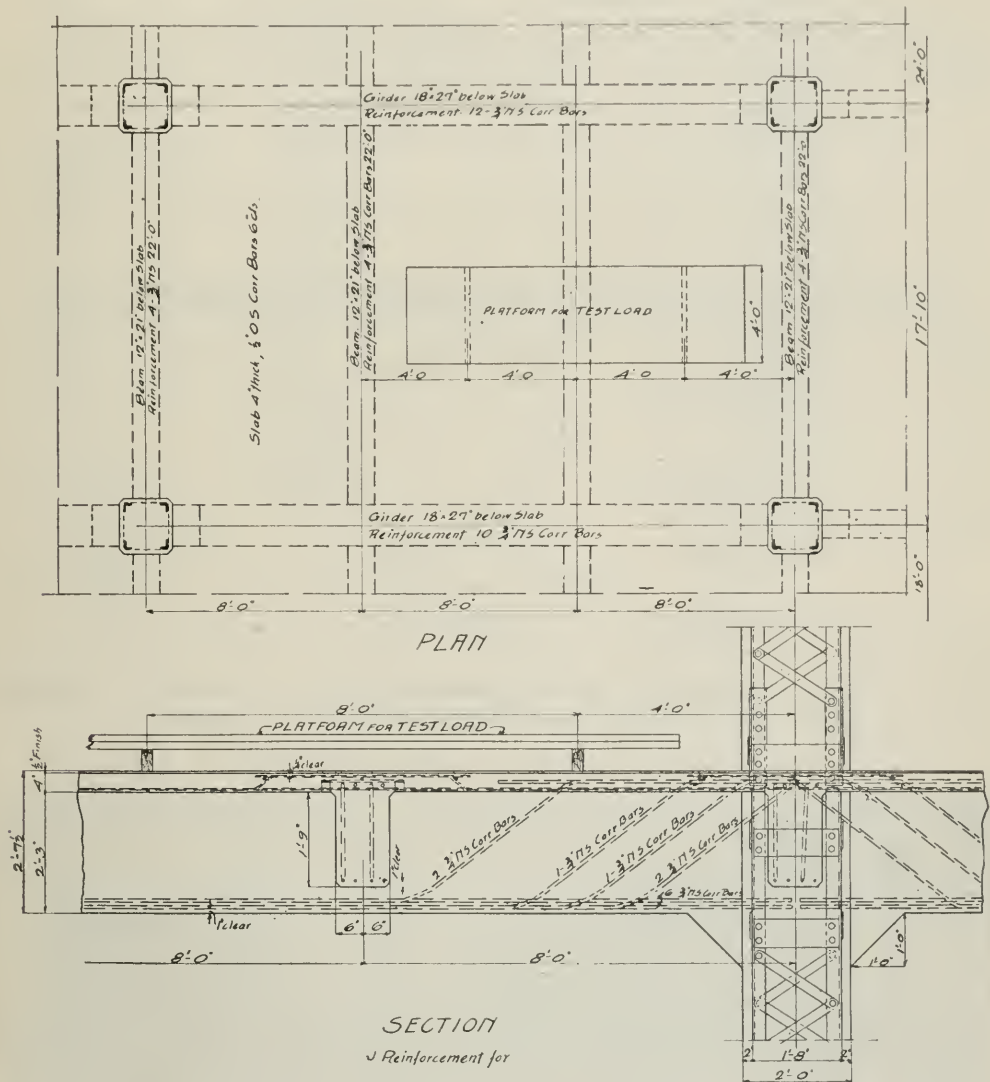


Fig. 28.—Typical Details of the Reinforced Concrete Construction of the Advance Thresher Company Building.

in this building were of concrete, reinforced with four angles latticed and were riveted together at their splices, permitting several stories of formwork to be carried on the columns ahead of the floor construction.

DISCUSSION.

The Chair: The subject of reinforced concrete is always one of great interest both in the general types in which it is carried on and in the special details of reinforcing bars, and so forth. It has been a subject of endless discussion and endless diversity of opinion among engineers. We have not had a meeting on the subject of

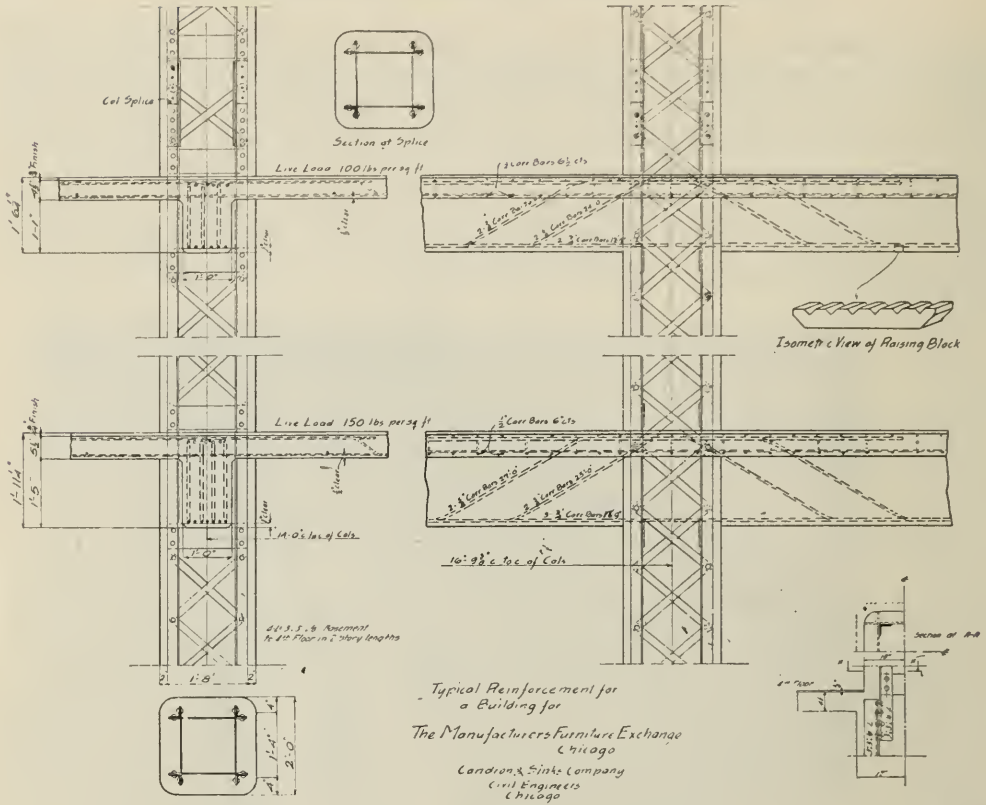


Fig. 29.—Typical Details of the Reinforced Concrete Construction of the Manufacturers' Furniture Exchange Building, Chicago.



Fig. 30.—First Floor and Column Reinforcement of the Manufacturers' Furniture Exchange Building.

reinforced concrete for a long time, and so I think it is certainly in order that that should have it at this time. Mr. Condrón has certainly developed a very interesting type of construction.

Mr. F. E. Davidson, M.W.S.E: I have listened with a good deal of satisfaction to Mr. Condrón's paper, and I will say that I have watched the construction of the building with a great deal of interest. Sometime early last spring Mr. Condrón very kindly invited me to look over the general drawings for this building, and I think I told him then, that he had done something that all engineers who were using reinforced concrete would be very much interested in; that he had developed a system of reinforced concrete for a flat slab construction which could be figured. That is one objection to such systems as Turner's where it is impossible to theoretically figure the strength of the slab. In the system that Mr. Condrón has designed, as he has stated, the strains can all be determined just as accurately as they can in a structural steel design. One thing that I like about this design—and it is a point that Mr. Condrón did not dwell on very much—that is, the cheapening very materially of the cost of the installation of sprinkler equipment. Another point: it certainly makes a better lighted building and a better appearing building than the ordinary system of joists and girders.

I would like to ask Mr. Condrón if he can give us any data as to the probable cost of this type of construction as compared to some other well known buildings which have been constructed of reinforced concrete. I would also like to ask as to the character of the enclosures around the elevator and stair walls and how those loads are carried. Are they simply light curtain walls or what is the method of enclosing elevator and stairways or are they enclosed at all?

Mr. W. A. Hoyt, M.W.S.E: I regret that I had not an opportunity to prepare for this discussion. It is certainly very interesting, but I was quite surprised when Mr. Condrón stated that the amount of steel required for the panel type was less than that for the joist and girder type. That is quite contrary to many designs, and is somewhat contrary to my opinion. I wish to ask if he could give the exact tonnage of steel required for each floor or for the total building, so that we may compare the amount of steel for the two types. It has sometimes seemed to me that there is too much stress or effort put forth to get this flat slab floor. It has, of course, a great many advantages, but it has seemed to me that those advantages have been sometimes rather over-estimated. Of course it makes a lighter building, but, as has been shown in a recent publication, claiming that the light was greatly obstructed by the beams, I think perhaps that it is somewhat overdrawn, for, in fact, the greater portion of the light comes in on a downward incline. Also, that perhaps in many classes of buildings it is the desire to have a plastered ceiling. Contractors do not always get perfect work and their ceilings are not always as sightly as they might be, and in certain factory buildings it is quite desirable to have the ceiling plastered. In that event it

seems to me that using the beam and joist type and plastering the ceiling gives a desirable ceiling, and desirable light. It gives, perhaps, under some conditions, a cheaper floor. Of course that depends largely on the contractor's equipment, his outfit, how extensive his work is, how frequently he can work his lumber over and all that sort of thing, as the salvage value of his lumber for his forms, etc. While my experience is somewhat limited, I like to save as much as possible at the start, and if I can, to economize in the forms, regardless of the salvage value. While that is worth something, of course, yet it is something that can not be of great value.

I would like to ask Mr. Condrón, what is a little apart from this discussion, his experience in putting on the finished floor, whether he gets better results by leaving this finish and putting it on after the floor has been finally cleared out, notwithstanding that it takes more material.

Mr. E. L. Jones, JUN., M.W.S.E.: I would like to ask the method of figuring the load at the edge of these wide beams, whether the deflection would not cause some difficulty in figuring the load on a wide beam.

Mr. E. McCullough, M.W.S.E.: Mr. Condrón speaks of the intersecting slabs and of course departs somewhat from the accepted nomenclature in calling them intersecting slabs when we would most of us be inclined to call them shallow beams; and in a conversation with Mr. Condrón to-day, he stated that that was all right, because a slab was simply a beam that was wider than it was deep and that simplifies the whole thing. I wish he had used the expression shallow beam or shallow girders in speaking of his floor, and then it might have been a little bit easier to have followed him, and then reserved the term slab for that interior panel section.

I believe quite a service has been done the profession in getting out a flat plate floor that permits of exact analysis. It is simply an extension of the beam and girder system of constructing reinforced concrete floors, because he uses wide shallow beams, and the broad panel surface is certainly pleasing and something that all owners want. I have found in the majority of cases that the claim is made by Mr. Turner and others who are advocating these mushroom floor systems that the owners are very anxious to get floors without beams and girders. The advantages that are claimed for them have been set out pretty well by Mr. Condrón. In the first place, you save in the total height of the building. That means something in the cost of construction, because there is some saving in the lifting of a great deal of material for the upper floors. The saving increases as the height of the building increases. We get a great deal better lighting effects. The permanent cost of lighting is reduced. There is less surface to collect dust; therefore it is easier to keep the building clean. The ventilation of the building can be decidedly improved and there is a constant annual saving in the expense of heating. I believe that a flat plate floor has so many advantages that the owners of buildings will seek more and more to obtain them. An obstacle

in the way, heretofore, of a more rapid introduction of such systems of building reinforced concrete has been the fact that the system so far used has been patented. I refer, of course, to the Turner mushroom floor.

Mr. Condron: I do not understand that a patent has been issued for that construction.

Mr. McCullough: Well, then, of course we are better off. The patent, I believe, is in the spreading head or column, but it is claimed to be patented, and it does not permit of exact analysis. Mr. Turner has lately produced a book, in which he shows that he has developed his system through a series of tests. Of course we all know that when we take a beam that has a great width in proportion to its depth that the deflection is a very important matter, and the most economical proportion of the beam in the reinforced concrete has generally been to get a width between two-thirds and three-fourths the depth, which has been about the stiffest and most economical beam we can get, and if you get, as in the case of Mr. Condron here, a beam that is about five or six times as wide as deep, * * *

Mr. Condron: Six feet wide and a foot deep.

Mr. McCullough: Six times as wide as deep, the deflection is quite an important matter, but at the same time it is something that permits of analysis and you can design those beams to take care of whatever deflection may be caused by putting that intermediate panel slab on the edges of the supporting slabs. I think the advantages of the girderless floor have been so well appreciated by the people who have been putting up these buildings that the principal thing in this paper is the fact that Mr. Condron and Mr. Sinks have given us something we can figure. Mr. Turner, it must be said, has been extremely fortunate in all the buildings that he has erected over the country, and if the men who have followed his lead and tried to produce floors that were just as good or exactly the same as his have not always been so fortunate; it may have been, perhaps, from a little too great anxiety to secure a contract and cut upon the material. We do not know what the real reason is, but we do know Mr. Turner has made tests that enable him to design safely, at any rate. The dead load is considerable. I made this afternoon some figures for my own satisfaction on a building that I know has been put up by the other system, and then figured it out according to Mr. Condron's plan, and know that the dead load can be and is considerably reduced.

Mr. A. W. Woodman, M.W.S.E: It certainly has been very interesting to notice the seven steps by which Mr. Condron has arrived at what his firm believes to be more or less of an ideal design, which was forecast, of course, in the sixth step, or the floor which was installed in the fertilizer plant at Hammond. It would appear from the views shown upon the screen that the only difference between that sixth step and the accepted design for the Studebaker Building, was the fact that the central portion of the panel was not recessed and that consequently the reinforcing material in the center portion

of the span was probably allowed to be lighter than was the case with the Studebaker Building. The most important thing of all, I think, is the fact that they are seeking to reduce the methods of computation to a more exact science than these have been in the past. There has been from the very beginning so much mystery in reinforced concrete and there has been so much made of the mysterious part of the thing in a commercial way, that in some places the use of the material has fallen into disrepute because of being exploited by people who were not strictly honorable. If the design which Mr. Condrón has shown to-night could be spread broadcast and if it could be made perfectly clear that the methods of designing are precise and accurate, there is little doubt but that the use of flat ceilings, at any rate as he has shown them, would become very general. I think the best part of this paper probably will be a reply which Mr. Condrón may be asked to make to the discussion to-night in the shape of giving us a little more exact details as to how his computations have been made. For instance, I think it would be very important for us to know how he provides for uniform distribution of load through his very wide girders, as his intersecting slabs are, of course, nothing but girders. It would also be interesting to know how he arranges for the distribution of the stresses through the central panel, and I trust that he will take pains to give us an answer in the discussion this evening, along these lines.

The Chair: One feature of Mr. Condrón's construction that commends itself most strongly to the owner and to the engineer in general practice, is the fact that the hideous outlines of most reinforced concrete structures have been eliminated. In place of that, we have a building uniform and neat in appearance on the inside; one that offers no obstruction to light in any direction, and in which you can obtain a clear, uninterrupted floor and ceiling without unsightly obstructions. This is an advantage we are coming to appreciate in this country more than we used to. Our neighbors in foreign lands realized this long before we did, and I think that those who have studied concrete construction abroad know that we are only beginning to build in concrete as we should. We are only beginning to make structures which are artistic, neat and appropriate in their outlines. This is natural, I think, because the first consideration has always been strength and we have been groping somewhat in the dark, and, as Mr. Woodman has said, the various patented forms of construction have been exploited one after another, each one with its secrets and its claims and without any intelligent method of calculation.

Mr. Davidson: About one year ago last June I was invited by a contractor to examine the construction of a reinforced concrete building which was being put up on Green Street, near Lake. The system of reinforcement used at that time was almost identical with the reinforcement Mr. Condrón has shown, except they had no beams or girders at all; they simply used a flat slab continuous from one side of the building to the other, but they put in an extra amount of

reinforcement over a space of about four feet. I shall be very glad to tell Mr. Condrón about it, who the engineer and the architect were, etc. I can not remember the names now. I was very much interested in it at the time and had some talk with the designer. I don't know how he figured it, but when the building was put up they tested it and I know it stood about three times the allowable load. I was there when the slab was tested. While the system had not been worked out as completely as Mr. Condrón has worked his out, the reinforcement was laid very similarly to the way that has been shown by Mr. Condrón.

There is one point I would like to call to the attention of Mr. Condrón and the other engineers, that I have done much thinking about and have been very much in doubt about, and I should be very glad of any assistance from any of the engineers as to how to figure or arrive at the depreciation rate on a reinforced concrete building. That is a question I am asked a great many times by owners as to why it would pay them to construct a reinforced concrete building over the old steel work with the hollow tile or even the old mill construction building. We know there is a certain salvage of steel and brick work; at least a mill construction warehouse will pay for tearing down. Suppose it becomes necessary to remove a concrete building. What is it going to cost? In other words, should not a depreciation rate be fixed and added up to the building every year to an estimated cost of removing a building, say in fifty years?

There is another point that I would like some assistance on, and that is some argument to try to convince a client that he should put up a fireproof building. You must remember that the mutual insurance companies will give exactly the same insurance rate on a modern mill construction building, with sprinkler equipment, that they will on a fireproof building. The argument comes to me: Why should we go to concrete or steel and tile when we get the same insurance rate on a mill construction building which costs much less?

These points may be a little beyond the discussion, but I would like to get some light on them.

The Chair: What was the distance between the columns in the building you just referred to?

Mr. Davidson: As I remember it, it was about 18 ft. 6 in. center to center, each way.

The Chair: Much less than in the construction presented by Mr. Condrón.

Mr. Davidson: Very much less than this long span; but it is of particular interest in forming the reinforced beams. The bars were arranged over a space of about four feet.

The Chair: In regard to the fire risk and the rate of insurance on a fireproof building as compared with a mill construction building, I might say that I have heard the same arguments in regard to steel construction, and I have always answered them by saying that you can seldom afford to burn up for your insurance. Any going concern has a great deal more than its visible assets in its business, and

no insurance can be written on its profits or good will. I think, in most cases at least, that this argument is enough to convince a man that it is best to use fireproof construction.

Mr. D. B. Lutin, M.W.S.E: The most striking thing about the views Mr. Condron has shown is the gradual development from the older type of beam construction to the flat ceiling with expanded column heads. I believe I am correct in saying that no man deserves more credit for developing that system than Mr. Turner of Minneapolis. Mr. Turner has worked consistently to the expanded column head and the flat slab, regardless of obstacles. He may not have been able to compute his slabs effectively; he has had all kinds of obstacles in his way; nevertheless, he has taken the consistent attitude of the commercial engineer and has designed and built what the people wanted. It seems to me that that is what the successful engineer must always do. He must furnish the salesman what the salesman can sell to his customer, and this Mr. Turner has done. Great credit, of course, is due to any engineer who shows a method of figuring such a system. But the reason that Mr. Turner stuck consistently to that attitude is undoubtedly because he owned patents, and it seems to me that that contradicts the statement of Mr. McCullough as to the effect of patents in developing reinforced concrete in the building industry. When Congress passed laws under which the Patent Office operates it had in mind the development of the various industries on which patents would be taken. Could it have been mistaken in assuming that patent protection would develop an industry?

One thing that is hardly clear to me in the comparison between the system Mr. Condron has illustrated and that of Mr. Turner is as to why one can not be computed mathematically and the other can. The system which Mr. Condron has shown has developed from the slab and beam systems which we do know how to compute, but the wide flat, shallow beams, have extremely eccentric loadings, which is exactly the difficulty in the Turner system. It is due largely to the eccentricity of loadings that the computation of that system is so difficult, and it would interest me greatly if Mr. Condron could give us some additional details as to the exact difference between the two systems in methods of computation. If the loads are carried to the columns in two directions at right angles to each other and in that way can be computed, could not that panel, or slab, then, be turned through forty-five degrees so that the lines of reinforcement and stress run directly to the column and thus assure us that the slab would have exactly the same strength as the other system? In other words, if Mr. Condron's method of construction is analyzable, does not that at once give a solution to Mr. Turner's system.

Mr. Woodman: Mr. Chairman, I think that can be answered right here. While I am not very conversant with the details of the Turner system, it is my recollection of it that the girders that are within the slab are diagonal, running from column to column crossing diagonally the square or the rectangle. That being the case, there are two

girders which are intersecting at the center, and there is therefore an indeterminacy which it is impossible to clear up, simply due to workmanship, if nothing else.

Mr. W. H. Finley, M.W.S.E: I was very much interested in Mr. Condrón's paper, particularly the way in which he showed the change from the beam and girder type to the flat construction and the illustration of what I would call, for want of a better name, a cantilever slab construction. There is no doubt in my mind that the type of construction illustrated by Mr. Condrón admits probably of a more accurate determination of the stresses in same, than the mushroom type that has been spoken of. There is no doubt in my mind, however, that Mr. Turner's mushroom type of construction can be made entirely adequate for all conditions and probably fairly economical, but there is no question, in my opinion, that it is absolutely impossible to make any theoretical analysis of the stresses in such construction. I believe, however, that it is possible to do so in the type illustrated by Mr. Condrón.

I believe that we shall be safer in reinforced concrete construction the closer we keep to types that can be analyzed on some rational basis.

Mr. McCullough: I had no intention to have my remarks construed as belittling in any way Mr. Turner's system, because I took occasion to remark that Mr. Turner had been very successful and has been very careful and conservative. But the fact remains that he has a system which at present—and he admits it himself—does not permit of exact analysis.

I have been waiting to hear somebody say something about the very direct method of transmitting stresses to the columns. That I think is a very important feature in this system of Messrs. Condrón & Sinks. It is certainly as simple as anything we could well conceive and it does not require a man with any great knowledge of structural mechanics to see that it is all right. In every system heretofore, that has contemplated a flat floor without beams and girders, the whole secret seems to have been centered in the highly elaborate forming of a head on a column. Mr. Martin of Messrs. Schmidt, Garden & Martin, architects, has designed a column head, and got patents for it a year ago. I have seen tests made on slabs designed according to his plan. The reinforcement is rectangular and parallel with the round columns, but it stops right there. The thing is a unit, the whole floor. Now, as Mr. Condrón very truly says, he has these intersecting slabs, going over the heads of the columns and the interior panel can be removed if necessary. Openings can be put in anywhere.

But the principal thing that Messrs. Condrón and Sinks should be commended for is that they have at last given engineers something tangible to work on, something that engineers can go to their clients with and tell them we have at last a floor of the kind that is a favorite with owners of buildings; capable of exact calculation, and that can

be checked by any capable designer and can also be tested and the results will be as predicted.

In regard to mill building construction, it is a very good idea that a man should not have to burn up in order to get returns for his insurance; but a serious thing has been discovered in mill buildings torn down lately, and that is the development of dry rot. That has not been suspected before, but it has been found to be a real danger. As a consequence the New England insurance companies I think, are looking a little askance at mill construction. Insurance ratings vary in different parts of the country. In some parts of the country fireproof buildings have a much better rating than slow burning mill construction.

Mr. Hoyt: I think there is one point that has not been spoken of that is quite an advantage. That is the massing of steel over the column head. When you come to putting the concrete in with the steel massed over the column, as you have in the Turner system, it requires a great deal of care to see that you get an accurate, careful combination of steel and concrete. Mr. Condron's system spreads the steel out more, and in that respect I think it is a decided improvement.

There is one other thing in regard to the matter of insurance. In several instances I have known of parties not having their buildings insured at all, when built of reinforced concrete, as they did not consider it necessary to insure the buildings. They insured the contents. But I think in a great many locations you can get quite an advantage in the insurance rate on a concrete building over that of the wood building, mill construction, and I think in a great many locations also you can get quite a reduced rate on the concrete building. A short time ago an article came out which showed workers in steel that they have some questions to decide yet as to the exact figuring of steel construction. I could not help thinking at the time, and I have thought it since many times, that the workers in concrete have not had so many odds to work against, and they are as capable of determining their strains closely as they are in steel construction.

Mr. Davidson: When I spoke of securing the same insurance rating on a mill construction building as on a concrete building, I spoke particularly upon the rating given by the Mutual companies. The Chicago Board of Fire Underwriters and the National Board here in Chicago, recently reduced their rate on fireproof buildings about fifty per cent, and it is true to-day that the Chicago Board of Fire Underwriters will give a very decided advantage to the fireproof over the mill construction, whether sprinkled or not. I had reference strictly to the Mutual companies.

There is one question I would like to ask Mr. Condron. That is, in figuring the dead weight of this slab construction whether any consideration is given for the additional amount of concrete finish which might be calculated for wearing surface: or if any calculation was made as to the renewing of the concrete finish, say in ten, fifteen

or twenty years, when the concrete surface will get worn off; or is the concrete finish figured as a part of the slab itself, or is it figured as a separate proposition and can be renewed at any time. It is a matter somewhat in doubt in my own mind as to how properly to figure those things.

Mr. Condron: No test load has been put on this building yet, but I went down to the building a week or ten days ago and as I walked in on the first floor I saw an area of about 60 ft. in length by from 15 to 18 ft. in width, covered with partition tiles. These tiles are 12 in. square, 6 in. thick, and they were piled up 11 and 12 high. I telephoned to the manufacturers and learned that these tiles weighed approximately 24 lb. each. Therefore, there was a load of from 264 to 288 lb. per sq. ft. all over that section of the floor, that was designed for a 100 lb. working load. The official test load has not been made, but this load was on for over two weeks without causing any sign of overstress. This has relieved my mind of any anxiety I might have had regarding the effect of a test load.

Regarding the question, when is a slab a girder, and when is a girder a slab, it seems to the speaker that a slab spanning between supports, is by common understanding a structural element, the width of which is great as compared to its depth. It is therefore a wide shallow beam. Hence he has referred to "intersecting slabs" in this construction because these elements here have a depth equal to but one-sixth of their width, that is, they are but 12 in. deep and over 6 ft. wide and their clear span is but three times their width.

This construction would not be possible with materials that cannot be so assembled as to provide continuous beam action over supports. That is, it is absolutely essential that this construction be in such material that tension is transmitted over the supports as well as between the supports. Otherwise it would not be reasonable to expect a beam having a depth of $1/24$ of the span, to carry the load without undue deflection, but by providing for continuous action over the supports the length of spans subject to deflection are reduced to about one-half the distance between supports. You will recognize at once that in reinforced concrete we have a material that is cast, and that has a combination of resisting elements in both its upper and lower faces.

Regarding the question as to cost of construction; this building was let on a lump sum contract, and the contractors have declined to divulge the separate costs. But enough has been said to the speaker by the contractors to indicate that this construction cost is a minimum for reinforced concrete. The speaker hopes to determine from this building something definite as to the cost of construction. As engineers, we can estimate the probable cost of the materials that go into the structure and the character of the work that has to be done. It is evident from the plans and photographs that it is an economical construction, but I cannot give a definite answer as to the cost data.

With reference to the question regarding enclosures around elevators, and other openings; these are of tile.

With reference to the weight of steel bars in the building; that is somewhat involved with stairways, spandril girders, arches in the front, and various other miscellaneous features. The total amounted to approximately 300 tons. The weight of the steel in the floor construction is about $5\frac{1}{2}$ lb. per sq. ft. of floor area.

The steel is a little less in the flat construction than in the girder beam and slab design. It would have greatly increased the amount of steel in the girder beam and slab construction had the girders been made of less depth than shown, but the reinforcing was restricted in the girders to 1% and in the floor slab to 0.8%. The flat construction was also limited to 0.8% reinforcement except in the intersecting slabs, in which 1% was used.

The amount of concrete in the girder and beam construction is somewhat less than in the flat construction.

It has been questioned if there is not a possible advantage in having beams in the ceiling instead of having a flat ceiling because sunlight does not come from the ceiling but comes from somewhere else and shines down on the floor. The answer to this is, do not neglect to take into account the great value of reflected light from a smooth ceiling. That is of very great importance, regardless of the source of light. A smooth ceiling gives better reflected light in any room at any time.

With reference to the remarks about plaster on the concrete, the speaker did not quite follow what was meant. We see a great many examples now of putting a thin coat of plaster directly on concrete surfaces, it is really quite common practice. Furring underneath the beams and having a false ceiling, is not necessary in this construction.

Salvage of lumber has been spoken of. Well, in any comparison between the salvage of lumber in this form of construction and the salvage of lumber in a construction requiring beam boxes the advantage will certainly be in favor of flat construction.

Regarding the question about wide beams (which we do not have, we have slabs) carrying their load across their whole width; the bars extending laterally across the upper face of the intersecting slabs reinforce them against flexure. If they cannot bend crosswise because of this reinforcing they must deflect as a unit and their loads will be distributed by shear across the width of these slabs.

Regarding details of calculation, the speaker did not attempt to go into these, not considering it necessary. He said the entire design met the requirements of the Chicago building ordinance. When one describes a plate girder and says it was designed in accordance with the specifications of the Maintenance of Way Association, engineers at once understand fully what was done. There is nothing peculiar or strange or involved in this. It is an ordinary engineering problem of moments and stresses, and has been calculated just as you figure

any moments and stresses, with the spans as they are given and the loads as they are required and the moments resulting from these. The usual straight line formula was used for determining the sections of concrete and steel.

The writer wishes to say a word upon a delicate subject; that is, of patents. He had a little discussion at dinner with a mechanical engineer and a civil engineer. This question came up and the mechanical engineer said that mechanical engineers always take out a patent on an improved machine; they are expected to do so and it is not considered unprofessional to do so. If a mechanical engineer designs and invents something that is an improvement in the art, his professional brethren expect him to protect that by a patent, and they do not think any the less of him if he does. But in the civil engineering profession, that has not been the usual case and it caused quite a little thought and discussion. We believe we have a very good thing, and the writer is more convinced of it than ever, since hearing the remarks here to-night. If Mr. Sinks has a patentable construction the speaker wants him to get it patented, because he deserves whatever he is entitled to in this particular case. The speaker gives Mr. Sinks full credit for this construction. It was his conception and his design originally. It has been worked out not only by Mr. Sinks but by the speaker and by several assistants in our office. We have all added, perhaps, a little here and there, but the original conception belongs to Mr. Sinks, and the speaker does not believe it would be discreditable to him to patent it, if it is possible for him to do so.

A remark was made about deflections in reinforced concrete. Professor Talbot says that in reinforced concrete building construction, it is practically impossible to figure or predict the deflection because it becomes a very involved proposition; therefore while you can figure it theoretically on a single span, you cannot do so under the involved conditions in a building.

Mr. Allen spoke about the architectural appearance of the construction, and that recalled the fact that an architect went to the building with the speaker recently and after looking it over, expressed great astonishment. He said, "Mr. Condron, I can't understand it. You say this is an engineering problem and yet you have arrived at a beautiful architectural effect." He seemed to think an engineering design ought to be ugly.

Mr. Davidson has referred to the building on Green Street. The speaker is very familiar with its construction, having been in the building several times; he knows the designer and knows how it was built; but don't know how it was designed. There are a number of features very different from what has been illustrated here. That building was built six or nine months after our experiments with the models described, so that Mr. Sinks did not get his ideas from that building. But the two constructions are quite dissimilar, although there is some similarity between them.

I was pleased that Mr. Lutin rose in defense of Mr. Turner. I

think Mr. Turner deserves a great deal of credit for the mushroom system. This paper was not on the mushroom system and it was hardly proper that it should be dragged in. Mr. Turner has done good work and has certainly built buildings that have stood up. The stresses in the mushroom floor system are indeterminate, all will admit that, because they are not only reinforced diagonally from column to column but are reinforced longitudinally and laterally, and that gives over the column heads from three to six thicknesses of steel intersecting at that point. In the center you have at least two thicknesses or more. In several places three or four thicknesses of steel intersect and you have so many lines for the stresses to follow that it is like a multiple intersecting truss and is indeterminate for that reason. If it was simply the diagonal bands we could determine the stresses perhaps, but the multiplicity of the bands makes it indeterminate. Nevertheless great strength can be secured in that way, and of course if the principal bands run diagonally across, then the maximum depth of the floor should be at the center of the panel.

The Chair: In regard to the remarks of the author of this evening relative to the patenting of his construction, I would like to say that I sincerely hope that he will obtain a patent if such protection is possible. I do not believe that it is unethical, I do not believe that any engineer would quarrel with him over it, and I believe that any engineer using a type of construction devised by another engineer ought to be perfectly willing to pay or have his client pay a fair royalty for it. We can only object to the patentee who charges an exorbitant royalty and who conceals his methods and the theory of his work. Where the matter is brought out in a professional way I think that we ought to agree, that the inventor of an improvement in the art is entitled to all he gets out of it, within reason.

A Visitor: I want to ask about this roof that has no roof covering other than the concrete. How long has that been there and is he wholly satisfied with it or whether he regards it as still being in the experimental stage.

Mr. Condron: The roofs of the Indianapolis Water Company are at least three years old. They are not at all in the experimental stage but a demonstrated success. The roofs for the Chicago City Railway Company, the first of which were built two years ago, are likewise a demonstrated success. There has been sent to the subcommittee on waterproofing of concrete of the Railway Engineering and Maintenance of Way Association a statement by one of the engineers of the Chicago City Railway, giving some very interesting facts with regard to their experience with reinforced concrete roofs without any other covering than the concrete itself. Their experience has been very satisfactory. That letter will be published in time. The success is due to a dense concrete and the reinforcement is so distributed, that the structure is fully reinforced against tension stresses wherever they may occur, due either to load or to temperature changes. When so designed and built, such roofs will prove

water-resisting for rain, though they may not sustain a head of several feet of water without leaking. In an area of about four acres, six or eight pin-hole leaks were found, which might cause damage in a dry goods store but do not do much harm in a car barn.

Mr. Moore: Mr. President, there is one question. It is not quite clear in my mind with reference to the comparative weight of steel used in the slab and beam construction. I understood Mr. Condron to say that in the slab construction they figured absolutely it would have to be a continuous girder in order to reduce the weight. I would like to ask if he figured his beam construction under the same conditions. I might suggest, in reference to the term for the slab, to call it a truss slab.

Mr. Condron: The arrangement of the reinforcing in the beams and the slab has nothing unusual about it. It is the common method of reinforcing concrete slabs and beams which in all cases were figured as continuous beams or continuous slabs.

The Chair: What was the minimum distance between the reinforcing bars and the bottom surface of the slabs, for fireproofing or protection of the steel?

Mr. Condron: The minimum protection under the slab reinforcement is $\frac{3}{4}$ in. of concrete under the round bars. Half of the bars being in a second plane they have $1\frac{1}{4}$ in. protection. The girder bars have $1\frac{1}{2}$ in. of protection. Concrete blocks were used for securing the bars in their position and these blocks are left permanently in the concrete, so that the position of the bars is quite fixed and there is little or no danger of the bars getting down against the forms, when thus supported.

Mr. Hoyt: How far are the slab rods run into the beam?

Mr. Condron: The rods of the enclosed slabs are carried at least $1\frac{1}{2}$ ft. into the intersecting slab. It will show on the drawing which will be reproduced with the paper.

The enclosed slab, in the typical case, is 17 ft. 6 in. square, and the building requirements are that the slab shall be figured for the clear span plus the thickness of the slab, which would make it 18 ft. 0 in. The span was figured as 18 ft. The column heads are 5 ft. wide. Therefore, the intersecting slabs have a clear span of 19 ft. between the column heads; they are 1 ft. thick, and according to the building requirements, they were figured for a 20 ft. clear span.

The design was figured exactly and closely in accordance with the rules laid down by the city building department; no variation was made from that in the least, so that it may be checked by any engineer who is familiar with the rules adopted for building construction by the building department of the city.

The Chair: I want to call attention to the author's answer to my question to the effect that there is from $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. of concrete protection outside of the steel. The comparison between fire-proofed steel construction, and reinforced concrete is not really under discussion this evening, but I have understood that tests made by the

National Board of Fire Underwriters and confirmed by observations made on the San Francisco fire have demonstrated that $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. is not sufficient fireproofing to protect steel, especially where the concrete contains lime, which slacks off under extreme heat. In any comparison between different types of construction I think this feature should be considered.

I know that it has not been customary to use more protection than stated by Mr. Condrón, in reinforced concrete work of this kind, but no discussion would be complete without calling attention to this most important question.

Mr. McCullough: Mr. Humphrey, at the last convention of the American Association of Cement Users, in their suggested building code, said that for ceilings $\frac{3}{4}$ in. protection was sufficient.

Mr. Condrón: That was based upon tests, was it not?

Mr. McCullough: That was on tests. For beams and girders they believed they should have not less than 1 to $1\frac{1}{4}$ in., and on columns 2 in. should be required. I believe that was the recommendation of the committee of the National Association of Cement Users: 2 in. for columns and $\frac{3}{4}$ in. for ceiling.

A Visitor: I would like to ask what quality of concrete cement they use, what size, and so forth.

Mr. Condrón: I avoided that feature, because I have never listened to a paper on concrete without about two hours being devoted to whether it should be a 1:2:4 or 1:2:4 $\frac{1}{4}$ or some other mixture of concrete. This was 1:2:4—one part Portland cement, two parts of torpedo sand (and in this case particularly good torpedo sand), and four parts washed gravel when they could get it, and when they could not, four parts of broken stone $\frac{3}{4}$ -in. size and under.

IN MEMORIAM

H. F. BALDWIN, M.W.S.E.

Henry Furlong Baldwin died on June 17, 1909, at Seattle, Washington, of apoplexy. He was born in 1862 and graduated at the Boston Institute of Technology in 1884. Mr. Baldwin was a brilliant engineer and was noted for his wonderful memory. Members of the Western Society of Engineers who came in contact with him knew him as an enthusiastic golfer, and a lover of keen, wholesome, manly sports.

He was a member of the Chicago Club, the Western Society of Engineers, the American Society of Civil Engineers, and numerous other clubs in the various towns where he held residence during his business life.

His first work was on the Cincinnati Division of the Louisville & Nashville Railroad from 1884 to 1888.5. After that for a brief period, he was Rail Inspector at various steel mills. From 1885 to 1887 he was Supervisor of Track of the Knoxville Branch of the Louisville & Nashville Railroad, and was Roadmaster of the Pensacola & Atlantic a short time in 1887. From 1887 to 1889, he was Roadmaster of the South & North Alabama Division of the Louisville & Nashville Railroad. From August, 1889 to March, 1890, he was Roadmaster of the Delaware Division of the New York, Lake Erie & Western Railway. From 1890 to 1894, he was Chief Engineer of the Chicago & Eastern Illinois Railroad. During this time a large portion of this road was rebuilt, involving a great deal of heavy work in the way of new masonry and bridge construction and reduction of grades, etc., also the construction of several new branch lines.

In May, 1894, he left the Chicago & Eastern Illinois Railroad to become Chief Engineer of the Chicago, Peoria & St. Louis Railway Company of Illinois at Springfield, which position he held until he accepted that of Engineer Maintenance of Way of the Erie Railroad, with office at Jersey City. He remained with the Erie Railroad until April, 1900, when he became Chief Engineer of the Chicago & Alton Railroad, with office at Chicago.

As Chief Engineer of the Chicago & Alton Railroad, he had charge of grade reduction, double track, and the general rehabilitation of the property during Mr. S. M. Felton's administration. In 1904, he left the railway field and took a position with the Dupont Powder Company and made his home at Wilmington, Delaware, in active charge of their numerous plants which distributed his work over a field from Maine to California. After two years of service with this Company he was appointed Chief Engineer of the Oregon & Washington Railroad of the Harriman lines, with headquarters at Seattle, which position he held at the time of his death.

As an example of his foresight as an Engineer, it might be cited

that when he was Chief Engineer of the Chicago & Eastern Illinois Railroad in 1894, he had his bridges designed for a loading about corresponding to Cooper's E-40, which was far ahead of the usual railway specifications for bridges of that date. At the time he was severely criticised for this but his executive officers had the good sense to uphold him in it and as a result many of these bridges, which were built at that time, are still in service under the heavy rolling stock of to-day, when, if he had built them for a lighter loading, as he had been counseled to do, the bridges would have had, ere this, to have been reconstructed.

Mr. Baldwin was a man of rugged, bluff, and intellectual honesty, and his loss will be greatly regretted by everyone who knew him well.

W. D. Taylor,
T. W. Snow,
Committee.

CARL WILLIAM BIRCH-NORD, M.W.S.E.

Died September 15th, 1909.

Carl William Birch-Nord was born in Christiania, Norway October 7th, 1880. He was graduated from the Christiania Elementary Technical School in 1899, and afterward completed a post-graduate course in Electrical Engineering at the Institute of Technology, Bingen, Germany.

In 1902, Mr. Birch-Nord came to the United States and settled in Chicago, Ill., where he held positions as Draftsman with Burnham and Company, the Metropolitan Elevated Railway Company. In June, 1903, he entered the service of the American Bridge Company, as Estimator and, later, as Assistant Engineer, in the Estimating Department of the Chicago Plant, where he remained until his death on September 15th, 1909.

On May 15th, 1907, Mr. Birch-Nord was married to Miss Marie Halvorsen, who survives him.

Mr. Birch-Nord was elected a Junior Member of the Western Society of Engineers December 9th, 1904, and an Active Member December 9th, 1907. He was also an Associate Member of the American Society of Civil Engineers.

Albert Reichmann,
Geo. N. Linday,
Committee.

WM. E. REYNOLDS, M.W.S.E.

Mr. Wm. E. Reynolds, a member of the Western Society of Engineers since 1904, died after a brief illness at his residence, 159 So. Homan Ave., Chicago, on the morning of Wednesday, Dec.

24th. Funeral service was held at the home of his parents in Mineral Point, Wis., on Friday, Feb. 26th.

Mr. Reynolds was born at Evansville, Wisconsin, Feb. 28, 1874. When quite young his parents moved to Mineral Point, Wis. He was a graduate of the Mineral Point High School with the Class of 1892. He was in business in Mineral Point until 1895, when he entered the University of Wisconsin, graduating from that university with the class of 1899 with the degree of Bachelor of Science in Electrical Engineering. Immediately after graduating he entered the Engineering Department of the Chicago Telephone Co., and at the time of his death was Engineer in charge of Central Office Switchboard Construction.

Mr. Reynolds was an engineer of considerable reputation in telephone circles. He was an active member of the U. W. Club of Chicago and at the time of his death was its Secretary. As an engineer he was known to be thorough and eminently practical. As a man he was most dearly beloved by all his friends and associates for his kindly manner and modest demeanor.

By his untimely death the engineering profession has lost a member of great promise.

J. G. Wray,
Committee.

PROCEEDINGS OF THE SOCIETY

MINUTES OF THE MEETINGS.

Regular Meeting Nov. 3, 1909.

A regular meeting of the Society (No. 673) was held Wednesday evening, November 3rd. The meeting was called to order about 8:30 P. M., with President Allen in the chair and about 55 members and guests present. The minutes of the meetings of October 6th and 20th were read and approved.

The Secretary reported from the Board of Direction that at their meeting of November 2nd the following had applied for membership:

Charles T. Barnum, Madison, Wis.....	Active
Charles A. Fingal, Chicago.....	Active
Rudolph W. Rusterholz, Chicago.....	Active
Jesse J. Walledom, Chicago.....	Junior
Thomas G. Windes, Jr., Chicago.....	Active
Edward Capouch, Chicago.....	Active
Frank Forest Sinks, Chicago.....	Active
William B. Greene, Chicago.....	Junior
Paul C. Seyl, Chicago.....	Junior
Arthur R. Eitzen, Chicago.....	Active
S. P. C. Borson, Laramie, Wyo.,.....	transfer to Active
John C. Augsburg, Chicago.....	Active
William T. Scantlin, Chicago.....	Junior
Alfred T. Tompt, Chicago.....	Active
Fred David Lyon, Chicago.....	Active
Bruce Sidmore, Chicago.....	Active
James H. Heald, Jr., Chicago.....	Active
Wilhelm Warnecke, Chicago.....	Active
Ben. Himan Bisbee, Chicago.....	Active
Homer A. Field, Chicago.....	Active
K. S. Landahl, Chicago.....	Junior
Carl A. Keller, Chicago.....	Active
Douglas B. A. Graham, Chicago.....	Active
Henry Warner Brown, Chicago.....	Junior
Herbert C. Dreher, Chicago.....	Active
Howard Bruce Murphey, Chicago.....	Active
Merle J. Trees, Chicago.....	Junior
D. Downey Williams, Chicago.....	Junior
Frank S. Chandler, Chicago.....	Associate
Ernest L. Clifford, Chicago.....	Active
J. W. Cowper, Chicago.....	Active
E. S. Stadelman, Chicago.....	Active
Herbert A. Fife, Chicago.....	Junior
Ejnar Frogh, Chicago.....	Junior
Arthur R. Shurtleff, Chicago.....	Associate
Paul H. Dratz, Chicago.....	Active
Frank Y. Johnson, Chicago.....	Junior
Bernhard Schroeder, Chicago.....	Junior
A. H. Cameron, Chicago.....	Junior
Frederick A. Potts, Empire, Panama.....	Active
J. F. Werlick, Chicago.....	Active
Frank H. Taylor, Chicago.....	Junior
Walter D. Guy, Chicago.....	Junior
William H. Alderson, Chicago.....	Active
Louis G. Arnold, Chicago.....	Junior
Paul P. Bird, Chicago.....	Active

Carl F. Convert, Chicago.....	Junior
Taliaferro Milton, Chicago.....	Active
Alexander M. Haubrich, Chicago.....	Active
Wm. J. Vanderkloot, Chicago.....	Transfer

Also that the following had been elected into membership:

Ralph A. Bonnell, Chicago.....	Active
Roy C. Mitchell, Chicago.....	transfer from Junior to Active
William F. Martin, Chicago.....	Active
J. B. Freeman, Chicago.....	Junior
Charles T. Barnum, Madison, Wis.....	Active
Charles A. Fingal, Chicago.....	Active
Jesse J. Walledom, Chicago.....	Junior
Edward Capouch, Chicago.....	Active
F. F. Sinks, Chicago.....	Active
Wm. B. Greene, Chicago.....	Junior
Paul C. Seyl, Chicago.....	Junior
Arthur R. Eitzen, Chicago.....	Active
Wm. T. Scantlin, Chicago.....	Junior
Fred D. Lyon, Chicago.....	Active
James H. Heald, Jr., Chicago.....	Active
Homer A. Field, Chicago.....	Active
Carl A. Keller, Chicago.....	Active
Henry W. Brown, Chicago.....	Junior
Merle J. Trees, Chicago.....	Junior
D. Downey Williams, Chicago.....	Junior

The Secretary also read from the minutes of the meeting of the Board of Direction, the following:

"The following petition for the creation of a Bridge and Structural Section, dated October 25th, and signed by twenty-eight Active members of the Society, was read:

"The undersigned Active members of the Society respectfully petition for the creation of a Section of the Society, to be known as the Bridge and Structural Section,' the object of which shall be the more complete study of matters pertaining to bridges and other structures.

"It is our desire to hold monthly meetings of this Section, for the months of September to June, inclusive, on such dates as will not interfere with other meetings of the Society or Sections, and as may be found most convenient."

"After considerable discussion, Mr. Brill offered the following resolution:

"Whereas, a petition has been presented to the Board of Direction for the formation of a Bridge and Structural Section;

"And whereas, the Board of Direction is of the opinion that this Section should be formed, in case sufficient interest is shown in its formation:

"Therefore, be it resolved, That the President of the Society be authorized to call a meeting of those interested in the formation of the Section, and if in his opinion sufficient interest is shown to indicate its success, to organize said Section in accordance with the By-laws.

"The resolution was adopted."

A portion of the minutes of the Regular Meeting of the Society of September 1st, pertaining to certain amendments to the Constitution and By-laws, was read, as follows:

"With the object of improving and making clear certain parts of the Constitution and By-laws of the Society, some amendments have been prepared by the Committee on Amendments. These were submitted to the Board of Direction at its meeting held August 31st and were ap-

proved, and are now presented to the Society in due form by petition, as provided for in the Constitution and By-laws.

"The object of the amendments to the Constitution, Article V, and to the By-laws, Articles I, II, and III, is to have more time between the close of the year and the Annual Meeting, and to give some days' interval between the election of the new officers and the Annual Meeting when they assume office, and to provide for a regular meeting of the Board of Direction for finishing the business of the past year and receiving the election returns.

"The object of the amendments to Article VI of the By-laws is to confirm, as a part of our organic law, the practice of the Board of Direction, during recent years of remitting dues of members of over thirty years' standing."

AMENDMENT TO THE CONSTITUTION.

ARTICLE V.

ANNUAL MEETINGS.

SECTION 1. The Annual Meeting shall be held on the first Wednesday after the first Thursday in January, at which time the results of the election of officers of the Society shall be announced, the Annual Reports received, and other business may be transacted.

AMENDMENTS TO THE BY-LAWS.

ARTICLE I.

SECTION 1. Omit everything after the word "quorum" so that the Section shall read "At the Annual Meeting of the Society twenty-five (25) Active members shall constitute a quorum."

ARTICLE II.

SECTION 8. Substitute "three (3) weeks" for "ten (10) days" where it occurs in the first line of this Section.

SEC. 10. Substitute "the Friday next before" in place of "the day of," where these words occur in the first line of this Section.

SEC. 12. Substitute "presented to the Board of Direction" for "handed to the President," where this word occurs in the last line of this Section.

ARTICLE III.

SECTION 2. Add the following paragraph after the fourth paragraph of this Article "The Board of Direction shall meet on the day fixed for closing of the polls, to receive and canvass the report of the Judges of Election and to transact such other business as may come before it."

ARTICLE VI.

SECTION 7. Substitute for the entire Section "The Board of Direction may, for good reason assigned, temporarily excuse any member from payment of annual dues, and said Board may remit the whole or part of dues in arrears or accept in lieu thereof desirable additions to the property of the Society."

SEC. 8. Substitute for the entire Section "Every person admitted to the Society shall be considered a member thereof and shall be liable for the payment of all dues until he shall have resigned, been expelled, or have been relieved from payment of said dues by the Board of Direction or by the provisions of these By-laws."

Amend by adding another Section, as follows:

SECTION 9. "Active members over sixty (60) years of age shall cease to pay dues after thirty (30) years of continuous membership."

There were no corrections or amendments offered, and on motion from

O. P. Chamberlain the meeting voted to adopt the amendments subject to a letter-ballot.

Announcement was made that as a vacancy had occurred in the office of Superintendent of Streets, an examination would be held December 6th by the Civil Service Commission, of candidates for this position, and that it had been considered desirable to advertise this matter before the members of the Society.

The President called attention to the very gratifying results due to work on the part of members of the Society, in increasing the number of applications for membership.

He also announced that a meeting would be held in the Society Rooms Wednesday, November 10th, to consider the organization of a Bridge and Structural Section, and that he hoped there would be a good attendance.

Mr. L. W. Page, Director of the Office of Public Roads, U. S. Department of Agriculture, Washington, D. C., was then introduced, who read his paper on "Macadam Roads and Their Preservation."

After the reading of the paper a number of lantern slide views were exhibited, showing the effect of high speed, heavy automobiles in the deterioration and destruction of macadam roads.

Discussion followed from Messrs. A. N. Johnson, State Highway Engineer for Illinois: A. W. Woodman, C. T. B. Goodspeed, A. C. Schrader, O. C. Simonds, O. P. Chamberlain, Linn White, W. A. Levering, J. F. Hayford, E. N. Layfield, K. B. Miller, W. H. Dean, and J. H. Warder, with a closure from the author of the paper.

On motion from Mr. K. B. Miller, a vote of thanks was tendered Mr. Page for his valuable paper.

Extra Meeting, November 10, 1909.

A special extra meeting of the Society (No. 674) was held Wednesday evening, November 10th, having been called to create and organize a Bridge and Structural Section.

The meeting was called to order at 8:30 p. m., with President Allen in the chair and about 65 members and guests present.

In opening the meeting the President explained that a petition, signed by twenty-eight active members, had asked for the formation of a Bridge and Structural Section in accordance with the by-laws of the Society. This request had been granted by the Board provided sufficient interest was manifested to insure success. The President also presented the arguments in favor of and against the formation of the Section.

A motion was made and carried unanimously that a Bridge and Structural Section be organized.

The next business before the meeting was the consideration of rules for the government of the Section, and on motion from Mr. Bement, the Section went into a Committee of the Whole, with Mr. Bement in the Chair.

In the Committee of the Whole, various plans for organizing were discussed, and the Committee finally adopted the recommendation that a temporary organization be formed, consisting of a Chairman, Vice Chairman, and three Directors, this Committee to recommend a permanent organization which should be undertaken at the next meeting.

The Committee then rose and reported to the Section, and nominations for the office of Chairman were called for. Mr. T. L. Condron was nominated and elected unanimously to the office. He was then inaugurated and took the Chair. Balloting then proceeded for the other officers, with the result that Mr. W. C. Armstrong was elected Vice Chairman, and Messrs. Andrews Allen, W. W. Curtis, and C. R. Dart, the three Directors of the Committee.

The meeting then adjourned to meet Wednesday, December 8th, at which time it is expected to have a technical paper, and also to form a permanent organization.

After adjournment some light refreshments were served.

December, 1909

*Joint Meeting, Electrical Section, and Chicago Branch A. I. E. E.,
Nov. 16, 1909.*

An extra meeting of the Society (No. 675), being a meeting of the Electrical Section W. S. E. (No. 45) held jointly with the Chicago Section A. I. E. E., was held Tuesday evening, November 16th, in Fullerton Hall, Art Institute.

The meeting was called to order at 8:10 p. m. by Past President W. L. Abbott, who remarked that there was present two Past Presidents of the Western Society of Engineers, three Past Presidents of the American Institute of Electrical Engineers, as well as the time honored Secretary (Mr. Pope) of the Institute. He also stated that in the aggregation of a Past President of the Institute and of the Western Society of Engineers, there was one who had been President of each Society, and to whom would fall the honor of presiding at this joint meeting, and he would call upon Mr. B. J. Arnold, to preside.

Mr. Arnold, upon taking the chair, welcomed those in attendance and congratulated them on what was before them. He also alluded to the presence of Mr. Pope, whom he introduced to the meeting. Mr. Pope spoke of the growth and development of the American Institute of Electrical Engineers, the youngest of the four great national engineering societies, and now the largest in numbers. He stated that this past summer, in the interests of the Institute and its sections, he had made an extensive trip over the country, visiting the local sections of the Institute, particularly on the Pacific Coast; he also expressed himself as being very happy in being present at this joint meeting, and hoped to be present on other occasions.

Mr. Arnold, in a few happy remarks, then introduced Dr. Charles P. Steinmetz, the speaker of the evening.

Dr. Steinmetz announced the subject of his address as "The Law of the Conservation of Energy." He illustrated his remarks with some blackboard sketches and mathematical formulæ, and showed that energy is never destroyed—only changed into some other form. A question was asked, that if a metallic spring—say a coiled spring of steel wire—be put in compression, which contained potential energy, and it then be placed in an acid bath which would entirely destroy the metallic spring as such, what became of the energy stored in the spring? Dr. Steinmetz said that the potential mechanical energy stored in the coiled spring was not destroyed, but was converted into an increase of heat energy, into chemical energy, and into electrical energy, and so was not lost.

The meeting adjourned about 9:20 p. m. There were about 500 present.

Extra Meeting, November 17, 1909.

An extra meeting of the Society (No. 676) was held Wednesday evening, November 17th. The meeting was called to order by President Allen at 8:30 p. m., with about 90 members and guests present. There was no business before the meeting.

The President announced the subject as Chicago's Smoke Problem, and introduced Paul P. Bird, Chief Smoke Inspector for Chicago. Mr. Bird then read his paper. Discussion followed from T. E. Donnelley, R. H. Kuss, W. F. M. Goss, E. J. Berg, S. G. Hobart, W. L. Abbott, A. Bement, Joseph Harrington, Charles Poethke (of Milwaukee), P. M. Chamberlain, W. D. Evans, C. F. Heal, and A. N. Johnson. The Secretary also read letters from G. F. Gebhardt and Wm. Wilbraham.

The meeting adjourned about 10:55 p. m., after approving the holding of an adjourned meeting in the near future, for further discussion of the subject, to give the operating engineers an opportunity to tell their side of the story.

Extra Meeting November 26, 1909.

A special extra meeting of the Society (No. 677) was held Friday evening, November 26th, adjourned from the meeting of November 17th, for further discussion and by the Operating Engineers, of "Chicago's Smoke Problem."

The meeting was called to order at 8:20 p. m., by the President with about 100 members and guests present.

After a few preliminary remarks from the President and from Mr. Paul P. Bird (the author of the paper presented at the preceding meeting), the discussion was opened by Mr. C. W. Naylor, M.W.S.E., following with remarks from Messrs. Hardin, Morrow, Johnson, McGrath, Elliott, Saxe, McNeil, Starr, Lightly, Strickler, Weber, Whyte, Shriner, Perry, Wolfinson, Heal, Norberg, Brown, Keenan, Mabbs, and Luehr. These were nearly all operating engineers of important Chicago power plants.

The meeting adjourned about 11:05 p. m.

Regular Meeting, December 1, 1909.

A regular meeting of the Society (No. 678) was held Wednesday evening, December 1st. The meeting was called to order about 8:25 p. m., with President Allen in the Chair and some 125 members and guests, including ladies, present.

The reading of the minutes of the preceding meetings was dispensed with by vote. The Secretary reported from the Board of Direction that the following had made application for membership in the Society:

George M. Shepard, Chicago.....	Junior
Alexander M. Graver, Chicago.....	Junior
Harry E. Wolfing, Chicago	Junior
Howard A. Sanstadt, Chicago.....	Active
John F. Hayford, Evanston.....	Active
Charles B. Trowbridge, Chicago.....	Active
Harry D. Keerl, Mason City, Iowa.....	transfer Active
Charles Piez, Chicago.....	Active
Robert F. Trumbull, Chicago.....	Junior
Chas. W. E. Clarke, New York.....	transfer Active
Herbert S. Graver, Chicago.....	Junior
Chas. A. Cleaver, Houston, Texas.....	Active
Arba B. Marvin, Chicago.....	Active
Allard Smith, Chicago.....	Active
Wm. A. Theodorson, Chicago.....	transfer Active
Austin Kimble, Chicago.....	Active
John B. Fink, Tulsa, Okla.....	Junior
John V. Zahlen, Chicago.....	Active
Wm. C. Bartholdy, Chicago.....	Active
Edward A. Kuehne, Chicago.....	Junior
Wm. H. Lewis, Chicago.....	Associate
Paul P. Stewart, Chicago.....	Active
Chas. F. Burgess, Madison, Wis.....	Active
Charles C. Wright, Chicago.....	Junior
Joseph O. Holzinger, Chicago.....	Junior
Bert G. Williams, Chicago.....	Active
Henry C. Breidert, Chicago.....	Active
Arrigo Young, Chicago.....	Junior
Irvin A. Bartholomew, Nyssa, Ore.....	Active
Archie J. Blakely, Nyssa, Ore.....	Active
Max N. Coles, Nyssa, Ore.....	Junior
Paul S. Roberts, Nyssa, Ore.....	Active
Joe D. Wood, Nyssa, Ore.....	Active
Samuel M. Felton, Chicago.....	Active
Thos. S. Hewerdine, Halifax, N. S.....	Active
Frederick H. Smith, Chicago.....	Active
Ralph H. Rice, Chicago.....	Active
Frank W. DeWolf, Urbana, Ill.....	Active
Jesse B. Wright, Tucson, Ariz.....	Active
George M. A. Ilg, Chicago.....	Active
Arthur T. Pravdiza, Chicago.....	Junior
Abel O. Anderson, Lake City, Iowa.....	Active

December, 1909

Society Notes

Also that the following had been elected into the Society:

Alfred T. Tompt, Chicago.....	Active
Ben H. Bisbee, Chicago.....	Active
K. S. Landahl, Chicago.....	Junior
Frank S. Chandler, Chicago.....	Associate
John W. Cowper, Chicago.....	Active
H. A. Fife, Chicago.....	Junior
Ejnar Frogh, Chicago.....	Junior
Frank Y. Johnson, Chicago.....	Junior
Bernhard Schroeder, Chicago.....	Junior
A. H. Cameron, Chicago.....	Junior
F. A. Potts, Empire, C. Z.....	Active
J. F. Werlich, Chicago.....	Active
Frank H. Taylor, Chicago.....	Junior
Walter D. Guy, Chicago.....	Junior
Wm. H. Alderson, Chicago.....	Active
Louis G. Arnold, Chicago.....	Junior
Paul P. Bird, Chicago.....	Active
Carl F. Convert, Chicago.....	Junior
Taliaferro Milton, Chicago.....	Active
A. M. Haubrick, Chicago.....	Active
George M. Shepard, Chicago.....	Junior
Alexander M. Graver, Chicago.....	Junior
Harry E. Wulfig, Chicago.....	Junior
John F. Hayford, Evanston, Ill.....	Active
Harry D. Keerl, Mason City, Iowa.....	transfer Active
Charles Piez, Chicago.....	Active
Robert F. Trumbull, Chicago.....	Junior
Herbert S. Graver, Chicago.....	Junior
Allard Smith, Chicago.....	Active
Wm. A. Theodorson, Chicago.....	transfer Active
John B. Fink, Tulsa, Okla.....	Junior
John V. Zahlen, Chicago.....	Active
Edward A. Kuehne, Chicago.....	Junior
Wm. H. Lewis, Chicago.....	Associate
Chas. F. Burgess, Madison, Wis.....	Active
Arrigo Young, Chicago.....	Junior

The Secretary reported from the Board of Direction that the letter ballots on certain amendments to the Constitution and By-Laws had been canvassed and that the votes cast had been almost unanimously in favor of the amendments; that these will be in force next year, 1910, and the annual meeting and dinner will be held the evening of Wednesday, January 12, 1910; also that the polls for the election of the officers of the Society will close at noon on Friday, January 7, 1910.

The Board of Direction also reported that the petitions for nominations of candidates for the offices of the Society resulted in the following nominations:

For President:

J. W. Alvord,
P. Junkersfeld,
Wm. B. Storey, Jr.

For First Vice-President:

A. Bement,
O. P. Chamberlain.

For Second Vice-President:

A. Bement,
C. H. Cartlidge,
Wm. B. Jackson.

For Third Vice-President:

W. K. Hatt, La Fayette, Ind.
A. Marston, Ames, Iowa.
H. M. Raymond, Armour Institute.

For Treasurer:

A. Reichmann.

For Trustee for Three Years:

W. W. Curtis,
G. A. M. Liljencrantz,
E. McCullough,
W. H. Pratt,
M. K. Trumbull.

The Secretary also announced that there would be a meeting of the Bridge and Structural Section on Wednesday evening, December 8th; also that a social meeting—a "Ladies' Night"—would be held Friday evening, December 10th.

There being no other business to bring before the Society, the President introduced Mr. George S. Rice, M.W.S.E., who read his paper on "Mine Accident Investigations of the U. S. Geological Survey," with a supplemental chapter on the Cherry mine disaster. The paper was illustrated with a number of stereopticon views.

Mr. R. Y. Williams followed Mr. Rice with an exhibit and explanation of the use of an oxygen helmet, furnishing a supply of oxygen to enable one to enter a mine filled with poisonous gases.

Discussion followed from Messrs. A. Bement, W. L. Abbott, H. H. Stock, Mr. Moore, and H. B. Gear.

The meeting adjourned about 11:10 p. m.

Extra Meeting, December 8, 1909.

An extra meeting of the Society (No. 679), being the second meeting of the Bridge and Structural Section, was held Wednesday evening, December 8th.

The meeting was called to order at 8:30 p. m., with Mr. T. L. Condon, Chairman, presiding and nearly 100 in attendance. The reading of the minutes of the meeting of November 10th was dispensed with by consent.

Rules for the Bridge and Structural Section had been prepared and copies distributed, and these were taken up, section by section, for consideration. Certain minor alterations were made and the rules as adopted are as follows:

Membership: 1. Members of the Western Society of Engineers of all grades shall be eligible to membership in the Bridge and Structural Section, and will be enrolled as members of this Section upon application to the Secretary. All members of the Section shall have the right to vote.

Officers: 2. The officers of the Bridge and Structural Section shall be a Chairman and a Vice Chairman, who shall be Active members of the Western Society of Engineers, and three Directors, who shall hold their respective offices for one year or until their successors are duly installed. These officers shall constitute an Executive Committee in which shall be vested the management of the Section.

3. The Chairman shall preside at all meetings of the Section and of the Executive Committee; in his absence the Vice Chairman shall preside; or, in the absence of both, a Director shall preside.

Meetings: 4. The regular meetings of the Bridge and Structural Section shall be held on the second Wednesday of each month, excepting July and August, unless this should conflict with some meeting of the Society, in which case the Executive Committee of the Section shall fix the date for the meeting. Special meetings of the Section may be called by the Chairman or Vice Chairman of the Section. The January meeting of the Section shall be the annual meeting. Fifteen members shall constitute a quorum at those meetings.

5. The meetings of the Executive Committee shall be held at least once a month at the call of the Chairman or Vice Chairman of the Section, at which meetings three members shall constitute a quorum.

Election: 6. The Chairman, Vice Chairman, and one Director shall be elected annually. The retiring Chairman and Vice Chairman shall not be immediately eligible for re-election to their respective offices, but they shall become Directors to serve for the ensuing year. In case the retiring Vice Chairman is elected Chairman, two Directors shall be elected to serve one year. In the first election three Directors shall be chosen to serve for one year. The Executive Committee shall fill, for the unexpired term, any vacancy occurring in its membership.

Nominations: 7. Nominations for officers, including at least two Directors, shall be made at the regular December meeting, and such nominations shall receive the endorsement of at least five members of the Section. Nominations shall be posted on the bulletin board in the Society's rooms and shall be voted upon by ballot at the annual meeting.

Amendments: 8. Any amendment proposed to these rules shall be reduced to writing, signed by at least three members and presented at a regular meeting of the Section. It may then be amended and shall be voted upon at the next regular meeting of the Section. If adopted by a majority vote it shall become effective.

Nominations for officers of the Section were then made, to be submitted to ballot at the next regular meeting of the Section, as follows:

Chairman, T. L. Condrón.

Vice Chairman, W. C. Armstrong.

Directors (three to be elected), Andrews Allen, C. R. Dart, F. E. Davidson, E. N. Layfield, S. T. Smetters.

This completing the business of the evening, the subject of the paper was announced, "The Eight Track Bascule Bridge at Campbell Ave. for the Sanitary District of Chicago." Mr. C. R. Dart, M.W.S.E., was introduced, who described the original structure and the one now under construction. He was followed by Mr. S. T. Smetters, M.W.S.E., who described more in detail some of the special features of construction of the new bridge.

A number of stereopticon views were shown illustrating the construction and appliances.

Discussion followed from Messrs. W. H. Finley, Geo. T. Horton, Andrews Allen, Theo. Kandeler, E. N. Layfield, and the Chairman.

The meeting adjourned at 11 p. m.

Social Meeting, December 10, 1909.

A social meeting—Ladies' Night—being a special extra of the Society (No. 680) was held in the Society rooms, Monadnock Block, Friday evening, December 10th, with Mr. P. Junkersfeld presiding, and about 125 members and guests present.

The program for the evening consisted of violin solos admirably rendered by Mr. C. E. Schaufler, M.W.S.E., with piano accompaniment, and of a recitative by Mrs. Andrews Allen, of Tennyson's "Guinevere" to a musical setting composed and executed on the piano by Mr. Henriot Levy, of Chicago.

After the completion of the program, Mr. Stern offered a vote of thanks from the audience to those who had done so much for their entertainment.

Refreshments were then served and the company dispersed about 11 p. m.

Extra Meeting, December 15, 1909.

An extra meeting of the Society (No. 681) was held Wednesday evening, December 15th.

The meeting was called to order at 8:20 p. m. by President Allen with about 95 members and guests in attendance.

There was no business before the Society, so Mr. T. L. Condrón, M.W.S.E., was introduced, who read his paper on "A Unique Type of Reinforced Concrete Building Construction." This was illustrated by a number of stereopticon views.

Discussion followed from the Chairman and Messrs. F. E. Davidson, W. A. Hoyt, E. McCullough, A. W. Woodman, D. B. Luten, W. H. Finley, E. N. Layfield, C. K. Mohler, E. L. Jones, and a closure from Mr. Condon.

The meeting adjourned about 10:50 p. m.

*Joint Meeting, Electrical Section and Chicago Branch A. I. E. E.,
December 22, 1909.*

An extra meeting of the Society (No. 682), being a meeting of the Electrical Section W.S.E. (No. 46), was held jointly with the Chicago Branch A.I.E.E. in the Society Rooms, Wednesday evening, December 22nd.

The meeting was called to order at 8:25 p. m., with Vice Chairman P. B. Woodworth presiding, and over 60 members and guests present. The minutes of the preceding meeting held November 16th were read and approved.

A portion of the Rules were read, showing that it was in order at this meeting to make nominations for three members of the Executive Committee of the Electrical Section for 1910, the same to be voted on at the annual meeting in January. Mr. James Lyman presented, by letter, the following names:

For Chairman, George H. Lukes.

For Vice Chairman, G. T. Seely.

For Member of Executive Committee to serve three years, P. B. Woodworth.

The Secretary suggested that he thought it wise to make certain changes in the Rules governing the Section, as follows: In paragraphs 6 and 7 change the date of meetings, regular and annual, from the *second Friday* to the *fourth Wednesday*, and thus have the Rules in accordance with the present practice. Attention was also called to the order and sequence of paragraphs 6 and 7, and the suggestion was made to exchange the order of these, so that paragraph 6 will relate to the regular meetings of the Electrical Section, and paragraph 7 will pertain to the annual meeting.

On motion of Mr. Roper this suggestion was approved, to be submitted to vote at the next regular meeting to be held Wednesday, January 26th, 1910.

The Chair made announcement that the policy of having joint meetings of the Electrical Section and the Chicago Branch A.I.E.E. had proved so satisfactory, that the joint committee desired to continue the arrangement, and had so voted. The Chair also stated that at the next joint meeting, to be held Wednesday, January 26th, Mr. Lee Campbell would address the meeting on "Recent Developments in the Automatic Telephone," etc.

There being no other business before the meeting, Mr. R. H. Rice was introduced, who read his paper on "Low Tension Feeder Systems for Street Railways." The paper was illustrated by a number of lantern slide views. Discussion followed from Messrs. Roper, Lake, Wheeler, and the Chairman.

The meeting adjourned at 9:35 p. m.

J. H. WARDER,
Secretary.

BOOK REVIEWS

CYRUS HALL McCORMICK. His Life and Work. By Herbert N. Casson. 5 by 8 in., 264 pages, including index. Frontispiece portrait and 17 photograveur full page illustrations. Cloth bound. Price \$1.50. A. C. McClurg & Co., Chicago, 1909.

This book consists of 13 chapters beginning with "The World's Need of a Reaper," and is followed by: "The McCormick Home in Virginia," "The Invention of the Reaper." "Sixteen Years of Pioneering" is followed by "The Building of the Reaper Business" and "The Struggle to Protect Patents." "The Evolution of the Reaper" precedes the "Conquest of Europe," following which we have "McCormick as a Manufacturer and as a Man." The chapters on "The Reaper and the Nation" and "The Reaper and the World," are impressive.

December, 1909

The book presents some astonishing facts as to the relation of wheat, as a food, to modern civilization, and the increase in quantity of this food, dependent upon the creation of the reaper which makes possible the harvesting of such immense quantities of the raw grain for the "staff of life."

The author claims that the making of the United States into a great nation has evolved with the dawn and growth of the industrial era, the replacing of muscle by machinery, and the establishing of better ways and better times on the farm and in the city. A reading of this book is necessary to a proper apprehension of our growth and development and our advance among the nations of the earth, by reason of our great supply of food-stuff for other peoples. This was possible by the invention of the reaper and its subsequent manufacture by American skill, which machinery, by its distribution among other nations, enables them also to be food-producers for themselves and the world.

It has been but a few weeks since the centennial anniversary of the birth of the great McCormick was suitably celebrated in the city of Chicago, yet what a marvelous change has come over the face of the whole world. It was in 1831 that the first successful and practical reaping machine was made, and that by the son of a Virginia farmer in a crude little farm work-shop. The reaper was successful as a reaper, but in the years since has been much modified in its form, construction, material, etc. The manufacture of reaping machines did not amount to anything for a dozen years or more, after 1831. It was in 1847 that McCormick came to Chicago and began the manufacture of reaping machines. Since then the development and enlargement of this business has been coincident with the growth of the city. But this book, so attractively written and printed, should be read, particularly as it throws so many valuable side lights on the growth and development of this business and consequently of our country.

W.

SOLID BITUMENS. By S. F. Peckham, A. M., Chemist to the Department of Finance, City of New York. The Myron C. Clark Publishing Co., New York and Chicago. E. & F. N. Spon, Ltd., London. 1909. Cloth, 6 by 9 ins.; pp. 324; illustrated. Price \$5.00.

In view of the increasing use of bituminous substances in the construction of pavements, any study of bitumens that places the subject in a clearer light is sure to be of great value to a large class of engineers. The subject is not a simple one. The analysis of ordinary bituminous substances is sufficient to tax the ingenuity of the skilled chemist. In fact, the investigation of bitumens provides many problems that have thus far baffled the most advanced chemical analysis. As stated by the author, it is "a field of vast extent and intricate paths, the boundaries of which no man living will discover."

With this statement in mind, the reader is not surprised to find that there are many questions in what may be called the theory of bitumens that the author discusses but does not attempt to settle; that many of his suggestions are tentative; and that portions of the work are valuable in furnishing material and stimulus for further investigation, rather than for the positive information that is given. It may be said, however, that this statement applies only to the theoretical study of the subject. The practical use of bitumen in pavements is a matter of good practice not hard to determine, though subject to constant improvement through theoretical investigation.

The ultimate object of the work is evidently a practical one—a study of "solid forms of bitumen and their uses in the construction of pavements." The latter portion of the work covers very fully the composition of paving material and the construction of pavements, as well as different methods of testing materials. But this work is far too broad in its scope to be classed as a book on pavements or paving materials.

A great deal of space is devoted to the origin, geographical distribution, and the physical and chemical properties of bitumen in its various forms. The reader who is not a chemist will meet some surprise in this portion of the work. Bitumen cannot be classified in a few words, nor by a simple chemical formula. It is defined as a hydro-carbon, containing often oxygen, nitrogen,

and sulphur in very complex compounds, "regarding which chemists have much to learn." It is widely distributed geographically, and occurs in many forms, usually mixed with other substances.

The classification of the different products and educts of bitumen has long been in an unsatisfactory state. Each investigator has made his own classification, apparently, and the matter has been further complicated by the nomenclature introduced through commercial necessity. In a chapter entitled "Classification of Bituminous Substances" this subject is thoroughly discussed and a logical classification and nomenclature is suggested.

The work will be useful to any engineer interested in paving, but its greatest value lies in the critical discussion of the whole subject of bitumens.

J. E. M.

COORDINATE GEOMETRY. By Henry Burchard Fine and Henry Dallas Thompson. The Macmillan Company, New York. 1909. Cloth, 7½ by 5 ins.; pp. 300; illustrated. Price \$1.60 net.

The book is divided into two sections, Coordinate Geometry in a Plane, and Coordinate Geometry in Space.

In the first section, chapters are devoted to the Straight Line, the Circle, the Parabola, the Ellipse, and the Hyperbola, giving the equation, shape, equation of the tangent at any point in the curve, and the focus of the different conics. Though rectangular coordinates are used principally, reference is made to oblique coordinates, and a chapter each is given to polar coordinates and the transformation of coordinates. The first section closes with a chapter on certain curves, not conics, giving equations and graphs.

The treatment of the second section of the book, covering about 100 pages, is similar to that of the first. Straight lines and planes in space, their equations, and the angles between them are discussed; the shape and equations of the several conicoids are also given; and chapters are devoted to polar coordinates and transformation of coordinates in space. The section closes with a chapter on the "General equation of the second degree," which includes a classification of the conicoids.

The book is well supplied with problems to be worked out by the student. The method of treatment is good, the diagrams are clear, and the work contains a half dozen excellent half-tones of the conicoids. The book is recommended to teachers and students interested in this subject.

J. G.

A MANUAL OF VOLUMETRIC ANALYSIS. By Virgil Coblenz, Professor of Chemistry, New York College of Pharmacy, and Anton Vorisek, Professor of Analytical Chemistry in the College of Pharmacy, Columbia University. P. Blakiston's Son & Co., Philadelphia. 1909. Cloth, 6 by 9 ins.; pp. 234, including index; 37 illustrations. Price \$1.75.

It is rather unusual, among the many scientific handbooks and other publications, to come across so thoroughly readable and interesting a text book as this work. The arrangement of the authors' material is such that the student has very little trouble in fixing the theory of volumetric analysis.

The general tone of the book is bright and very clear; the theory of the application, very simple.

Particularly is one impressed with the importance of Chapter I, and its painstaking survey of the little necessary details that simplify, while at the same time strengthen them. The accuracy of all volumetric actions—one of the great criticisms of the average chemical hand book—is regarding the absence of such detail under the impression that every reader will be equally able to read between the lines. In this case such information is so thoroughly and interestingly handled that the earnest reader will never go far wrong once the authors' ideas are embodied in his chemical understanding.

The theory of indicators in Chapter II is—in the reviewer's mind—one of the best, most complete and enlightening expositions he has ever had the good fortune to read. In fact, the entire structure of the authors' work is such that the reader's ideas are established logically and accurately, and

while there is not present the great mass of detailed application, the theory is so firmly established that this absence is rather a satisfaction than otherwise.

W. A. C.

METALLURGY OF THE COMMON METALS (Non Ferrous). By A. Humboldt Sexton, Professor of Metallurgy Glasgow and West of Scotland Technical College, and John S. G. Primrose, Prin. Asst. Metallurgical Dept. Glasgow and West of Scotland Technical College. The Scientific Publishing Co., Manchester, Eng. Cloth, $5\frac{1}{2}$ by $8\frac{1}{2}$ ins.; pp. 483; many illustrations. Price, 7s 6d.

This little book, as its title states, is devoted to the common metals, other than iron, namely, copper, tin, zinc, lead, antimony, aluminum and nickel, and is intended as an introduction only, or, as it might better be called, a summary. A list of larger works on the subjects, with a brief statement of the nature of each, is contained in an appendix.

The typographic work is excellent, and the arrangement, with catch words and phrases in black faced type, most convenient.

The matter is clearly and concisely stated, and there is a vast amount of information in condensed and accessible form. The good index at the end of the volume cannot be too highly commended. Such an index doubles the value of any work.

In some places the authors might, with advantage, have been more explicit. For example, the statement that aluminum alloys readily with most metals, should have been accompanied by the further statement that only those of its alloys are of value which contain a considerable excess of one of the constituents; the intermediate alloys mostly disintegrate and are worthless.

The omission of any date of publication or completion must be criticised. This is very common in English works, and is a most reprehensible practice. People are entitled to know when their eggs were laid.

On the whole the book fills a want and is most welcome, and the authors are to be congratulated on their work.

W. S. B.

MECHANICS' AND MACHINISTS' POCKET BOOK AND DIARY. 1910. By William H. Fowler. The Scientific Publishing Co., Manchester, Eng. Cloth; 4 by 6 ins.; pp. 448. Price 6d net.

This is the second edition of a little book of the kind, that is much valued by the general mechanic, machinists, millwrights, tool makers and even draftsmen, who are in want of some practical information. Its low price puts it within the reach of everybody, and even the young men in this country who have at times worked under the reviewer have liked these moderate priced English books.

The contents are almost the same as in the last edition: After the usual mathematical tables, there was inserted a chapter on logarithms and a popularly written instruction to use them. Their application in form of mechanical and pocket calculators is also new. The paragraph on drilling and boring metal has been abridged probably without doing any harm. "Emery and Emery Wheels" stands without change, and seems to have room for a little up-to-date information on grinding and grinding materials. Miscellaneous tools and appliances have not been treated upon in this edition, and it seems to be as well, as their number is endless if looked at in the light of previous edition. The addition of several tables on screw threads, bolt nuts, etc., makes the book more valuable, although the new edition, as well as the old one, has the great drawback of having the index, table of contents, list of advertisers, etc., scattered through the advertisements, and some of the latter ones are even to be found in the text.

All together, the book is very useful to the practical mechanic, whom it is intended for.

H. G.

CONCRETE INSPECTION. By Charles S. Hill. A manual of information and instructions for inspectors of concrete work, with Standard and Typical Specifications. 4 by 6 ins.; pp. 179, with index and illustrations. Cloth

bound. Price \$1.00. The Myron C. Clark Publishing Co., New York and Chicago. 1909.

"Careful inspection is a vital factor in securing safe and enduring concrete work. No matter how well the engineer may design, his work will come to naught unless his design is accurately carried out by careful and skillful workmanship with good materials." And it is to secure such results is the duty of the inspector. Hence this book on Concrete Inspection is an attempt in the right direction.

The inspector on concrete work is often one of the most troublesome problems with which the honest and experienced contractor has to deal; also to the architects he can be of great help or a constant source of annoyance. Unfortunately most inspectors on concrete work are not well informed and have little practical judgment, and altogether too frequently they possess many of the weaknesses of mankind.

Therefore, a book which gives general information and aids to a practical judgment could well have a brief chapter on the duties, rights, and limitations of the inspector. Such a book, cheap in cost, is certainly needed.

The aim of the book before me is to give in a brief form the general information, calling attention to the reasons and relative importance of the various rules given. The book shows careful selection of reliable material in accord with the latest practice. It is suggested, however, that for a later edition the value of the book could be enhanced by drawing more from practical experience, and giving the young inspector pointers as to actual conditions which occur all along the line. The conscientious young man, imbued with the customary opinion that all contractors are thieves, and not knowing what to expect from materials or men, is certainly in need of practical suggestions.

W. A. H.

LIBRARY NOTES.

The Library Committee wishes to express thanks for donations to the library. Back numbers of periodicals are desirable for exchange and in completing valuable volumes for our files.

Since the issue of the JOURNAL for October, 1909, we have the pleasure to report the following additions to the library and gifts from donors named:

MISCELLANEOUS GIFTS.

Chicago Academy of Sciences:

Fall Announcement, September, 1909. Pam.

University of Tennessee, Knoxville, Tenn.:

Manual for Engineers. v. p. 1.

Railroad Age Gazette, Chicago.

Biographical Directory of Railroad Officials of America. Cloth.

Locomotive Dictionary. Cloth.

Railroad Signal Dictionary. Cloth.

John Wiley & Sons, New York.

Structural Details, Jacoby. Cloth.

Concrete, Plain and Reinforced, Taylor and Thompson. Cloth.

New Jersey State Board of Health:

32nd Annual Report, 1908. Cloth.

D. W. Mead, M.W.S.E., Madison, Wis.

An investigation of the Hydraulic Ram. Pam.

C. L. Strobel, M.W.S.E., Chicago.

A Treatise on Masonry Construction, Baker. 1889. Cloth.

R. R. Commissioners, State of Iowa.

Annual Report, 1908. Cloth.

Education Commissioners, State of Illinois:

Final Report, 1909. Cloth.

State Geologist of West Virginia:

Vol. IV. West Virginia Geological Survey, 1909. Cloth.

L. K. Sherman, M.W.S.E., Chicago:

Message of President R. R. McCormick, Sanitary District of Chicago. Pam.

Sewerage of the Calumet District. 1909.

E. E. R. Tratman, M.W.S.E., Chicago:

Report on the Union Elevated R. R. of Chicago, Mohler. Pam.

Statistical tables of the working of Railways in the various countries to 1904. Pam.

Report Presented at International Street Railway Congress 1906. Pam.

Proceedings of International Street Railway Congress 1906. Pam.

International Tramway Union Convention, Munich, 1908. Folio.

University of Illinois Bulletin, September, 1908. Pam.

Roadmasters' Maintenance of Way Association of America, Proceedings, 26th Annual Convention, 1908. Pam.

American Railway and Maintenance of Way Association, Bulletin, Dec., 1908.

Water Supply and Irrigation Papers Nos. 227, 232, 233, 242.

International Congress of Street Railways and Lights Rys. 1908. Paper.

Annual Report of South Australian Railway Commission. 1908-9. Paper.

- Sanitary District of Chicago:
 Proceedings, 1907, 1908. 2 cloth.
- Ralph Modjeski, M.W.S.E., Chicago:
 Estimate of Bridge across the Willamette River at Portland, Ore. Pam.
- Board of Water Supply, New York:
 Second Annual Report, 1907. Cloth.
- Herbert N. Casson, Pine Hill, N. Y.:
 "Cyrus H. McCormick, His Life and Work." Casson. Cloth.
- McGraw Publishing Co., New York:
 The McGraw Electrical Directory, leather.
 The McGraw Electrical Directory, Lighting and Power Edition. Leather.
- M. C. Clark Publishing Co., Chicago:
 Concrete Inspection, Hill. Cloth.
 Graphic Statics, Malcolm. Cloth.
 Solid Bitumens, Peckham. Cloth.
 Concrete Bridges and Culverts, Tyrrell. Leather.
 Cost Keeping and Management Engineering, Gillette and Dana. Cloth.
- Metropolitan Sewerage Commission, New York:
 Digest of Data Collected before 1908 Relating to Sanitary Condition of New York Harbor. Pam.
- Canada Geological Survey:
 Report on Whitehorse Copper Belt, Yukon Territory. Pam.
 Coal Fields of Manitoba, etc. Pam.
 Reports, Algoma and Thunder Bay Districts. Pam.
 Catalogue of Publications, Geological Surveys of Canada.
 Report of Iron Ore Deposits along the Ottawa and Gatineau Rivers. Pam.
- John Crerar Library, Chicago:
 A List of Books in the Reading Room of the John Crerar Library. Paper.
- Bion J. Arnold, M.W.S.E., Chicago:
 1st Annual Report, Board of Supervising Engineers, Chicago Traction, 1908. Cloth.
- Sanderson & Porter, New York:
 The Stanislaus Power Development Sierra & S. F. Power Co. Pam.
- Boston Chamber of Commerce, Boston, Mass.:
 The Buying and Handling of Steam Coal. Pam.
- F. P. Kellogg, M.W.S.E., Chicago:
 The Army and Navy Club, Washington, D. C., 1905. Cloth.
- Illinois State Geological Survey:
 Bulletin No. 11, Physical Features of the Desplaines Valley. Cloth.
- Bureau of Surveys, Philadelphia, Pa.:
 Annual Report, 1908. Cloth.
- State Geological Survey, North Dakota:
 Fifth Biennial Report, 1908. Pam.
- Boston Transit Commission:
 Fifteenth Annual Report to June 3rd, 1909. Cloth.
- Carl C. Witt, M.W.S.E., Pierre, S. D.
 17th, 18th and 19th Annual Reports of Board of Railway Commissioners of South Dakota. 1906-7-8. 3 cloth.
- J. W. Beardsley, M.W.S.E., New York.
 Preliminary Report on Irrigation in Java, Beardsley. Pam.
- C. H. Benjamin, La Fayette, Ind.
 The Steam Engine, Benjamin. Cloth.
- Boston Street Department, Boston, Mass.:
 Annual Report for 1908. Cloth.

- Cambridge Commission, Boston, Mass.:
 Cambridge Commission Report. Cloth.
 Department of Buildings, Louisville, Ky.:
 Building Code of City of Louisville. Cloth.
 Bituminous Coal Trade Association, New York:
 Bituminous Coal, Production, Shipments, 1908. Pam.
 D. Van Nostrand Co., New York:
 Electric Power Conductors. Del Mar. Cloth.
 The Century Co., New York:
 Municipal Government. F. J. Goodnow. Cloth.
 J. H. Warder, Sec'y.
 Plant Breeding. L. H. Bailey. Cloth.
 Garden-Making. L. H. Bailey. Cloth.
 The Life and Letters of Faraday. Bence Jones. Vols. 1
 and 2. Cloth.
 Society of Chemical Industry, London. Annual General
 Meeting, 1905. Cloth.
 The Railways and the Republic. J. F. Hudson. Cloth.
 The Western Horticultural Review, 1851. J. A. Warder,
 Vols. 1, 2, 3. Cloth.
 Hedges and Evergreens. J. A. Warder, 1858. Cloth.
 Weights, Measures, and Money of All Nations. F. W. Clarke,
 1875. Cloth.
 The Improvement of Towns and Cites. C. M. Robinson.
 1901. Cloth.
 Civil Service in Great Britain. D. B. Eaton. 1880. Cloth.
 Kentucky Geological Survey, Reports of Progress, 1875. Cloth.
 Kentucky Geological Survey, Report of survey made during
 1858-9. Cloth.
 New York Commissioners of Fisheries, Game and Forests,
 1st, 2nd, and 3rd annual reports, 1895-7. Cloth.
 U. S. Commission of Fish and Fisheries, Reports, 1873-6,
 1878, 1887. Cloth.
 U. S. Bureau of Ethnology, 5th annual report, 1883-4. Cloth.
 U. S. Dept. of Interior, Supt. of Documents, Index of Pub-
 lications of U. S. G. 1839-1893. Cloth.

GOVERNMENT PUBLICATIONS.

- U. S. Geological Survey, Dept. of Interior. Pams.
 Bulletins Nos. 360, 373, 377, 380, 382-4, 387-8, 392-4, 401-3,
 412, 423.
 Production of Mineral Paint in 1908.
 Production of Coal in 1908.
 Production of Glass Sand, other sand and gravel in 1908.
 Production of Iron Ore, Pig Iron and Steel in 1908.
 Production of Antimony, Arsenic, Bismuth, etc., in 1908.
 Production of Tungsten, Nickel, Cobalt, etc., in 1908.
 Production of Platinum in 1908.
 Production of Silver, Copper, Lead and Zinc in Central States.
 Production of Gold, Silver, Copper, Lead and Zinc in Eastern
 States.
 Production of Lead in 1908.
 Production of Copper in 1908.
 Production of Minerals in 1908.
 Production of Zinc in 1908. Smelter production.
 Production of Cadmium in 1908.
 Production of Quicksilver in 1908.
 Statistics of Clay Working Industries in 1908.
 Water Supply and Irrigation Papers Nos. 232, 234, 235, 242.
 Professional Papers Nos. 64, 66.
 The Stone Industry and Manufacture of Lime in 1908.

Department of Commerce and Labor:

Tight Cooperage Stock in 1908. Pam.
 Marriage and Divorce, 1867-1906. Part I. Cloth.
 Mortality Statistics 1908. Pam.
 Lumber, Lath and Shingles in 1908. Pam.
 Veneers in 1908. Pam.

U. S. Senate:

University of the United States, 1906. Pam.
 Report on Establishment of University of United States. Pam.
 University of United States, 1902. Pam.

Library of Congress:

Want List of Publications of Societies. Pam.
 Want List of Periodicals. Pam.

Department of Agriculture:

The Status of Forestry in the U. S. Pam.
 Year Book 1908. Cloth.
 Forest Service Circular No. 171.

Bureau of Education:

Bulletins of Bureau of Education from 1906 to date. 23 Pams.
 Report of Commissioner of Education for year ending
 June 30, 1909.

War Department:

Tests of Metals, 1908. Cloth.
 Report upon the Improvement of Rivers and Harbors in the
 First Chicago District. By Maj. T. H. Rees. Pam.

Navy Department:

Annual Report of Chief of Bureau of Steam Engineering,
 1909. Pam.

Interstate Commerce Commission:

Bulletins of Revenues and Expenses of Steam Roads in the
 U. S. for 9 months ending March 31, 1909. 4 pams.

Isthmian Canal Commission:

The Isthmian Canal. By H. H. Rousseau. Pam.

MEMBERSHIP

Additions to membership:

Alderson, Wm. H., 135 Adams St., Chicago.
 Arnold, Louis G., 1021 Dearborn Ave., Chicago.
 Barnum, C. T., U. S. Forest Service, Madison, Wis.
 Bird, Paul P., 1365 E. 48th St., Chicago.
 Bisbee, Ben. H., 1218 Chamber of Commerce, Chicago.
 Brown, Henry W., American Bridge Co., Chicago.
 Burgess, Charles F., Madison, Wis.
 Cameron, A. H., American Bridge Co., Chicago.
 Capouch, Edward, American Bridge Co., Chicago.
 Chandler, Frank S., Commonwealth Edison Co., Chicago.
 Convert, Carl F., C., M. & St. P. Ry. Co., Chicago.
 Cowper, John W., Worden-Allen Co., Chicago.
 Eitzen, Arthur R., American Bridge Co., Chicago.
 Field, Homer A., American Bridge Co., Chicago.
 Fingal, Chas. A., Hansell-Elcock Co., Chicago.
 Fife, Herbert A., Commonwealth Edison Co., Chicago.
 Fink, John B., Oklahoma Iron Works, Tulsa, Okla.
 Freeman, Julian B., Robins New Conveyor Co., Chicago.
 Frogg, Ejnar, 2613 N. Maplewood Ave., Chicago.
 Graver, A. M., Graver Tank Works, East Chicago, Ind.
 Graver, H. S., Graver Tank Works, East Chicago, Ind.
 Greene, Wm. B., Robins New Conveyor Co., Chicago.
 Guy, Walter D., 2309 Osgood St., Chicago.

December, 1909

Haubrich, Alex. M., Stromberg-Carlson Tel. Co., Chicago.
Hayford, John F., Northwestern University, Evanston, Ill.
Heald, James H., Jr., American Bridge Co., Chicago.
Johnson, Frank Y., Sargent & Lundy, Railway Exchange, Chicago.
Keerl, Harry D., Engineer and Contractor, Mason City, Iowa.
Keller, Carl A., Commonwealth Edison Co., Chicago.
Kuehne, Edward A., 11148 Indiana Ave., Chicago.
Landahl, K. S., American Bridge Co., Chicago.
Lewis, Wm. H., F. J. Lewis Mfg. Co., Chicago.
Lyon, Fred D., City Erection Co., Chicago.
Martin, Wm. F., Scherzer Rolling Lift Bridge Co., Chicago.
Milton, Taliaferro, Electric Storage Battery Co., Chicago.
Mitchell, Roy C., 440 Fullerton Ave., Chicago.
Piez, Charles, Link Belt Co., Chicago.
Potts, F. A., Empire, C. Z., Panama.
Scantlin, Wm. L., Ingersoll-Rand Co., Chicago.
Schroeder, Bernhard, Sargent & Lundy, Chicago.
Seyl, Paul C., Robins New Conveyor Co., Chicago.
Shepard, George M., C. M. & St. P. Ry., Chicago.
Sinks, Frank F., Condron & Sinks, Chicago.
Smith, Allard, Chicago Telephone Co., Chicago.
Taylor, Frank H., Geo. P. Nichols & Bro., Chicago.
Theodorson, Wm. A., C. & N. W. Ry. Co., Chicago.
Tompt, Alfred T., American Bridge Co., Chicago.
Trees, Merle J., Chicago Bridge & Iron Works, Chicago.
Trumbull, Robert F., Universal Portland Cement Co., Chicago.
Walledorn, Jesse J., American Bridge Co., Chicago.
Werlich, Julius F., Commonwealth Edison Co., Chicago.
Williams, D. D., Chicago Bridge & Iron Works, Chicago.
Wulfing, Harry E., Cosmopolitan Electric Co., Chicago.
Young, Arrigo, 1629 Pierce Bldg., St. Louis, Mo.
Zahlen, John V., Sargent & Lundy, Chicago.

WESTERN SOCIETY OF ENGINEERS

SECRETARY'S OFFICE, LIBRARY, READING ROOM AND MEETING ROOMS
1735 Monadnock Block, Chicago.

LIST OF OFFICERS FOR 1909

President.....ANDREWS ALLEN
First Vice-President P. JUNKERSFELD
Second Vice-President.....O. P. CHAMBERLAIN
Third Vice-President.....W. F. M. GOSS
Treasurer....A. REICHMANN

TRUSTEES

W. C. ARMSTRONG.....Term expires January, 1910
L. E. RITTER Term expires January, 1911
G. M. BRILL ..Term expires January, 1912
B. J. ARNOLD, W. L. ABBOTT, C. F. LOWETH.....Past Presidents.

The above named officers of the Society and three past presidents, constitute its Board of Direction.

Secretary and Librarian
J. H. WARDER

COMMITTEES

On Finance—P. Junkersfeld, A. Reichmann, John Brunner
On Publication—O. P. Chamberlain, C. B. Burdick, Wm. B. Jackson,
A. Bement, Ernest McCullough, E. N. Layfield, M. K. Trumbull, O. J. West.
On Library—W. C. Armstrong, L. J. Hotchkiss, E. N. Lake.
On Amendments—C. F. Loweth, W. L. Abbott, B. J. Arnold,
W. T. Reeves, M. K. Trumbull.
On Membership—L. E. Ritter, C. M. Denise, D. W. Roper.
On Entertainment—G. M. Brill, W. A. Hazard, James Lyman.
On Increase of Membership—S. T. Henry, F. W. Boldenweck,
C. W. Brooks, Arthur Lewis, M. W. Priseler.

THE ELECTRICAL SECTION

Wm. B. Jackson, Chairman, P. B. Woodworth, Vice-Chairman, for 1909.
K. B. MILLER.....1 year
E. N. LAKE 2 years
W. L. ABBOTT.....3 years
Members of Executive Committee.

MEETINGS

Regular Meeting—1st Wednesday evening of each month except January
July and August.
Extra Meeting—Generally the 3rd Wednesday evening of each month except
July and August.
Electrical Section—Wm. B. Jackson, Chairman, generally the 2d Friday of
the month, October to May, inclusive.
Board of Direction—The Tuesday preceding the 1st Wednesday of each month.

NOTICE

From the dues of each member, \$2.00 is set aside as a subscription to the JOURNAL.

INDEX

Vol. XIV.—January to December, Inclusive.

1909.

	PAGE
A Unique Type of Reinforced Concrete Construction. T. L. Condon, M.W.S.E.	822
Abbott, W. L., M.W.S.E. Discussion of A. Bement's paper on "The Illinois Coal Field."	333
Discussion of H. H. Evans' paper on "Electrification of Railway Terminals"	198
Accident (Mine) Investigations of the U. S. Geol. Survey. Geo. S. Rice, M.W.S.E.	782
Adgate, George. Memorial	609
Allen, Andrews, M.W.S.E. Remarks made as chairman of Reminiscence Meeting held March 24, 1909.	281
Remarks as President-elect of W.S.E.	117
Annual Reports	124
Arnold, B. J., George Weston, and H. B. Fleming, Members W.S.E., Phases in the Development of the Street Railways of Chicago.	641
Babcock, A. H., Discussion of paper on "Relation of Load Factor to Power Costs."	256
Bainbridge, F. H., M.W.S.E. Discussion of J. F. Jackson's paper on "Stability of Dams."	633
Baldwin, Henry F. Memorial	863
Bates, Onward, M.W.S.E. Address at annual meeting, 1909.	118
Bement, A., M.W.S.E. The Illinois Coal Field.	305
Birch-Nord, C. W. Memorial	864
Boiler Corrosion as an Electrochemical Action. C. F. Burgess.	375
Book Reviews	129, 286, 620, 714, 875
Breckenridge, L. P., M.W.S.E. The Engineering Experiment Station and Its Relation to Illinois Industries	487
Discussion of A. Bement's paper on "The Illinois Coal Field."	355
Bridge Erection with Derrick Cars. J. H. Prior, M.W.S.E.	449
Briquetting, Coal. Carl Scholz	137
Buchanan, Gordon. Discussion of A. Bement's paper on "The Illinois Coal Field."	329
Burdick, C. B., M.W.S.E. Discussion of J. F. Jackson's paper on "Stability of Dams."	637
Burgess, C. F. Boiler Corrosion as an Electrochemical Action.	375
Caissons—Concrete-Steel. Their Development and Use for Breakwaters, Piers, and Revetments. Maj. W. V. Judson.	533
Camp, W. M. Discussion of H. H. Evans' paper on "Electrification of Railway Terminals."	199
Chanute, Octave, M.W.S.E. Remarks in response to his election as an honorary member	116

	PAGE
Chicago Harbor. The. John M. Ewen, M.W.S.E.....	745
Chicago Street-Car Tracks; Reconstruction of. George Weston, M.W.S.E. . .	673
Chicago Street Railways; Phases in the Development of. B. J. Arnold, H. B. Fleming, George Weston.....	641
Chittenden, H. M. Discussion of C. McD. Townsend's paper on "Improve- ment of the Upper Mississippi River".....	70
Clarage, E. T. Discussion of Mr. Potter's paper on "Manganese Steel"....	239
Coal Briquetting. Carl Scholz.....	137
Coal Field; the Illinois. A. Bement, M.W.S.E.....	305
Coatings (Protective) for Structural Material. R. S. Perry.....	399
Concrete (Reinforced) Construction; A Unique Type of. T. L. Condon, M.W.S.E.	822
Concrete-Steel Caissons; their Development and Use for Breakwaters, Piers and Revetments. Maj. W. V. Judson.....	533
Condon, T. L., M.W.S.E. A Unique Type of Reinforced Concrete Construc- tion	822
Corrosion (Boiler) as an Electrochemical Action. C. F. Burgess.....	375
Crerar (John) Library	439
Dams; Some Observations on the Stability of. J. F. Jackson, M.W.S.E.	625
Derrick Cars and Bridge Erection. J. H. Prior, M.W.S.E.....	449
Development of Street Railways of Chicago. B. J. Arnold, H. B. Fleming, George Weston	641
Developments in Electrification of Railway Terminals. H. H. Evans.....	155
De Wolf, Frank W. Discussion of A. Bement's paper on "The Illinois Coal Field."	339
Dodge, Grenville M. Engineering in the West in Early Days and During the War	I
Electrification of Railway Terminals. H. H. Evans.....	155
Electrochemical Action; Boiler Corrosion as an. C. F. Burgess.....	375
Elevated Tanks and Stand Pipes; Water Storage in. H. E. Horton, M.W.S.E.	418
Engineering Experiment Station (The), and Its Relation to Illinois Indus- tries. L. P. Breckenridge, M.W.S.E.....	487
Engineering in the West in Early Days and During the War. Gen. Gren- ville M. Dodge	I
Engineering Work of the Wisconsin Tax and R. R. Commissions. W. D. Pence, M.W.S.E.	73
Evans, H. H. Electrification of Railway Terminals.....	155
Ewen, John M., M.W.S.E. The Chicago Harbor.....	745
Experiment Station (Engineering), and Its Relation to Ill. Industries. L. P. Breckenridge, M.W.S.E.	487
Finley, W. H., M.W.S.E. Discussion of J. F. Jackson's paper on "Stability of Dams."	637
Fleming, H. B., M.W.S.E. Discussion of George Weston's paper on "Recon- struction of Street-Car Tracks in Chicago.".....	692
Fleming, H. B., B. J. Arnold, George Weston, Members W.S.E. Phases in the Development of the Street Railways of Chicago.....	641
Gilchrist, John F. Discussion of paper, "Relation of Load Factor to Power Costs"	251

Index to Volume XIV

PAGE

Goss, W. F. M., M.W.S.E. Discussion of L. P. Breckenridge's paper on the Univ. of Ill. Engineering Experiment Station.....	529
Green, Paul E., M.W.S.E. Discussion of George Weston's paper on "Reconstruction of Street-Car Tracks in Chicago.".....	693
Harbor, Chicago. John M. Ewen M.W.S.E.	745
Horton, H. E., M.W.S.E. Water Storage in Elevated Tanks and Stand Pipes	418
Houghteling, James. Address at annual meeting 1909.....	119
Howlett, C. A. S., M.W.S.E. (E. W. Lloyd and J. M. S. Waring). Relation of Load Factor to Power Costs.....	241
Hudson, C. H., M.W.S.E. Address at Reminiscence Meeting March 24, 1909.....	267
Illinois Coal Field. A. Bement, M.W.S.E.....	305
Illinois Engineering Experiment Station. L. P. Breckenridge, M.W.S.E....	487
Improvement of the Upper Mississippi River. Col. C. McD. Townsend, M.W.S.E.	26
Iron and Steel Sections; Special Rolling. Willis McKee.....	729
Irrigation (National) Congress, 1909.....	707
Jackson, J. F., M.W.S.E. Some Observations on the Stability of Dams.....	625
Jackson, W. B., M.W.S.E. Discussion of paper, "Relation of Load Factor to Power Costs."	253
Johnston, Thomas T. Memorial.....	612
John Crerar Library	439
Josephson, Aksel G. S. The John Crerar Library.....	439
Judson, Maj. W. V. Concrete-Steel Caissons; their Development and Use for Breakwaters, Piers and Revetments.....	533
Judson, W. V. Discussion of C. McD. Townsend's paper on "Improvement of Upper Mississippi River".....	65
Junkersfeld, P., M.W.S.E. Discussion of H. H. Evans' paper on Electrification of Railway Terminals	175
Katte, Walter, M.W.S.E. Letter read at Reminiscence Meeting held March 24, 1909	270
Kelker, R. J., Jun. M.W.S.E. Discussion of George Weston's paper on "Reconstruction of Street-Car Tracks in Chicago.".....	697
Lake, E. N., M.W.S.E. Discussion of H. H. Evans' paper on "Electrification of Railway Terminals."	177
Library Notes	132, 299, 446, 724, 880
Lloyd, E. W. (C. A. S. Howlett and J. M. S. Waring). Relation of Load Factor to Power Costs.....	241
Load Factor; Relation of, to Power Costs. E. W. Lloyd, C. A. S. Howlett, J. M. S. Waring.....	241
Loweth, C. F. Address as retiring president of W.S.E.....	114
Loweth, C. F., M.W.S.E. Discussion of J. H. Prior's paper on "Derrick Cars and Bridge Erection."	480, 485, 486
Lyman, James, M.W.S.E. Discussion of H. H. Evans' paper on "Electrification of Railway Terminals."	178
Manganese Steel. W. S. Potter.....	212
McKee, Willis. The Rolling of Special Sections of Iron and Steel.....	729
Membership	302, 447, 728, 883

Index to Volume XIV

	PAGE
Memorials—	
Adgate, George	609
Baldwin, Henry F.....	863
Birch-Nord, C. W.	864
Johnston, Thomas T.	612
Reynolds, Wm. E.	864
Schaub, J. W.	436
Smith, Charles A.	113
Tutton, Charles H.	112
Mine Accident Investigations of the U. S. Geological Survey. George S. Rice, M.W.S.E.	782
Minutes of Meetings	114, 283, 444, 617, 711, 866
Mississippi River, Upper; Improvement of. C. McD. Townsend, M.W.S.E.	26
Morehouse, L. P., Hon. M.W.S.E. Address at Reminiscence Meeting March 24, 1909	262, 273
Morgan, Richard Price, M.W.S.E. Letter read at Reminiscence Meeting held March 24, 1909	269
National Irrigation Congress, 1909.....	707
Nicholl, T. J., M.W.S.E. Letter read at Reminiscence Meeting held March 24, 1909	270
Officers of the Society	136, 304, 448
Paige, Alonzo W., M.W.S.E. Letter read at Reminiscence Meeting held March 24, 1909	274
Pence, W. D., M.W.S.E. Work of Joint Engineering Staff of the Wisconsin Tax and R. R. Commissions.....	73
Perry, R. S. Protective Coatings for Structural Material.....	399
Phases in the Development of the Street Railways of Chicago. B. J. Arnold, H. B. Fleming, George Weston.....	641
Potter, W. S. Manganese Steel.....	212
Power Costs; Relation of Load Factor to. E. W. Lloyd, C. A. S. Howlett, J. M. S. Waring.....	241
Prior, J. H., M.W.S.E. Derrick Cars and Bridge Erection, with Some Tests of Iron Pulley Blocks.....	449
Protective Coatings for Structural Material. R. S. Perry.....	399
Pulley Blocks (Iron), Tests of. J. H. Prior, M.W.S.E.....	449
Railroad and Tax Commissions (Wisconsin). Work of Engineering Staff. W. D. Pence, M.W.S.E.	73
Railroad Situation of To-day, The. Frank Trumbull.....	18
Railway Terminals; Electrification of. H. H. Evans.....	155
Railways (Street) of Chicago; Development of. B. J. Arnold, H. B. Fleming, George Weston	641
Ray, Walter T., M.W.S.E. Discussion of A. Bement's paper on "The Illinois Coal Field."	335
Reconstruction of Street-Car Tracks in Chicago. George Weston, M.W.S.E.	673
Reinforced Concrete Construction; A Unique Type of. T. L. Condon, M.W.S.E.	822
Relation of Load Factor to Power Costs. E. W. Lloyd, C. A. S. Howlett, J. M. S. Waring.....	241

Index to Volume XIV

	PAGE
Reminiscence Meeting, March 24, 1909	262
Rensselaer Polytechnic Institute; Opening of Russell Sage Laboratory....	710
Reynolds, Wm. E. Memorial.....	864
Rice, George S., M.W.S.E. Mine Accident Investigations of the U. S. Geol. Survey	782
Rice, George S., M.W.S.E. Discussion of A. Bement's paper on "The Illinois Coal Field."	343
Rolling of Special Sections of Iron and Steel. Willis McKee.....	729
Roper, D. W., M.W.S.E. Discussion of H. H. Evans' paper on "Electrifica- tion of Railway Terminals."	179
Sawyer, Geo. L., M.W.S.E. Report on National Irrigation Congress, 1909....	707
Schaub, J. W. Memorial.....	436
Scholz, Carl. Coal Briquetting.....	137
Sewall, J. S., M.W.S.E. Letter read at Reminiscence Meeting held March 24, 1909	280
Sherman, L. K., M.W.S.E. Discussion of J. F. Jackson's paper on "Stability of Dams."	635
Smith, Charles A. Memorial.....	113
Smith, G. W., M.W.S.E. Discussion of J. H. Prior's paper on "Derrick Cars and Bridge Erection".....	477
Some Observations on the Stability of Dams. J. F. Jackson, M.W.S.E.....	625
Special Sections of Iron and Steel; Rolling of. Willis McKee.....	729
Stand Pipes and Elevated Tanks; Water Storage in. H. E. Horton, M.W.S.E.	418
Stability of Dams; Some Observations on. J. F. Jackson, M.W.S.E.....	625
Steel (Manganese). W. S. Potter.....	212
Steel and Iron Sections; Special Rolling. Willis McKee.....	729
Storage of Water in Elevated Tanks and Stand Pipes. H. E. Horton, M.W.S.E.	418
Storey, W. B., Jr., M.W.S.E., Discussion of H. H. Evans' paper on "Electrifi- cation of Railway Terminals".....	181
Street Car Tracks in Chicago; Reconstruction of. George Weston, M.W.S.E.	673
Street Railways of Chicago; Phases in the Development of. B. J. Arnold, H. B. Fleming, George Weston	641
Structural Material; Protective Coatings for. R. S. Perry.....	399
Symons, W. E., M.W.S.E. Discussion of J. H. Prior's paper on Derrick Cars and Bridge Erection	482
Symons, W. E., M.W.S.E. Discussion of W. S. Potter's paper on "Man- ganese Steel"	232, 236
Symons, W. E., M.W.S.E. Discussion of H. H. Evans' paper on "Electri- fication of Railway Terminals".....	186
Tanks (Elevated) and Stand Pipes; Water Storage in. H. E. Horton, M.W.S.E.	418
Tax and Railroad Commissions (Wisconsin). Work of Engineering Staff. W. D. Pence, M.W.S.E.....	73
Taylor, E. H. Discussion of A. Bement's paper on The Illinois Coal Field..	346
Terminals (Railway); Electrification of. H. H. Evans.....	155

Index to Volume XIV

	PAGE
Townsend, Col. C. McD. Discussion of Maj. Judson's paper on Concrete-Steel Caissons	605
Townsend, C. McD., M.W.S.E. Improvement of the Upper Mississippi River	26
Tracks (Street Car) in Chicago; Reconstruction of. George Weston, M.W.S.E.	673
Tratman, E. E. R., M.W.S.E. Discussion of A. Bement's paper on The Illinois Coal Field	343
Trumbull, Frank. The Railroad Situation of Today.....	18
Tutton, Charles H. Memorial.....	112
U. S. Geol. Survey Mine Accident Investigations. Geo. S. Rice, M.W.S.E....	782
Univ. of Ill. Engineering Experiment Station. L. P. Breckenridge, M.W.S.E.	487
Waring, J. M. S. (E. W. Lloyd and C. A. S. Howlett). Relation of Load Factor to Power Costs.....	241
Water Storage in Elevated Tanks and Stand Pipes. H. E. Horton, M.W.S.E.	418
Weston, George, M.W.S.E. Reconstruction of Street Car Tracks in Chicago	673
Weston, George, B. J. Arnold, and H. B. Fleming, Members W.S.E. Phases in the Development of the Street Railways of Chicago.....	641
Weston, John W., M.W.S.E. Letter read at Reminiscence Meeting held March 24, 1909	275
Williams, Benezette, M.W.S.E. Remarks made at Reminiscence Meeting of March 24, 1909.....	269
Williams, R. Y. Discussion of A. Bement's paper on The Illinois Coal Field	345
Wisconsin Tax and R. R. Commissions; Work of Joint Engineering Staff. W. D. Pence, M.W.S.E.....	73
Work of the Joint Engineering Staff of the Wis. Tax and R. R. Commissions. W. D. Pence, M.W.S.E.....	73
Wright, A. W., M.W.S.E. Letter read at Reminiscence Meeting held March 24, 1909	274

BOOK REVIEWS.

Aids to Shippers. Oelrichs & Co.....	296
Artificial Waterways and Commercial Development. A. B. Hepburn.....	288
Azimuth. George S. Homer	621
Bricklaying System. Frank Gilbreth	718
Co-ordinate Geometry. H. B. Fine and H. D. Thompson.....	877
Concrete Inspection. Charles S. Hill.....	878
Design and Equipment of Small Chemical Laboratories. R. K. Meade....	292
Design of Highway Bridges and the Calculations of Stresses in Bridge Trusses. M. S. Ketchum	286
Earth Slopes, Retaining Walls, and Dams. Charles Prelini.....	289
Electrical Engineers' Pocket Book of Useful Data for Electricians and Electrical Engineers. Horatio A. Foster.....	130
Elements of Physics. E. L. Nichols and W. S. Franklin.....	291

	PAGE
Engineers' Pocket Book of Reinforced Concrete. E. Lee Heidenreich.....	295
Exercises in Surveying, for Field and Office Work. J. C. Tracy.....	624
General Lectures on Electrical Engineering. Charles P. Steinmetz.....	623
Guide to Technical Writing. T. A. Packard.....	129
Heat Energy and Fuels. H. V. Juptner.....	620
Hydraulic Tables. G. S. Williams and Allen Hazen.....	290
Irrigation Engineering. H. M. Wilson	719
Laboratory Notes on Industrial Water Analysis. E. H. Richards.....	130
Law and Business of Engineering and Contracting. Charles Evan Fowler.....	714
Manual of Volumetric Analysis. Virgil Coblentz.....	877
Manual for Engineers. Charles E. Ferris.....	720
McCormick, Cyrus Hall. His Life and Work. H. N. Casson.....	875
Mechanics' and Machinists' Pocket Book and Diary. Fowler.....	878
Metallurgy of the Common Metals. A. H. Sexton.....	878
Modern Methods of Street Cleaning. Geo. A. Soper.....	718
Portland Cement Industry from a Financial Standpoint. E. C. Eckel.....	294
Practical Calculations of Transmission Lines. L. W. Rosenthal.....	292
Practical Sheet and Plate Metal Work. E. A. Atkins.....	290
Problems of City Government. L. S. Rowe.....	721
Railroad Structures and Estimates. J. W. Orrock.....	622
Remaking the Mississippi. J. L. Mathews.....	620
Reservoirs for Irrigation. J. D. Schuyler.....	294
Simplified Methods of Calculating Reinforced Concrete Beams. Noble Twelvetrees	621
Solid Bitumens. S. F. Peckham	876
Theory and Design of Reinforced Concrete Arches. Arvid Reuterdaahl.....	130
Theory and Practice of Bridge Construction. M. W. Davies.....	291
Trade Catalogues	296, 723
Treatise on Masonry Construction. Ira O. Baker.....	719
When Railroads Were New. C. F. Carter.....	716

BINDING SECT. AUG 14 1980

TA
1
W52
v.14

Western Society of
Engineers, Chicago
Journal

Engin.

ENGINE STORAGE

**PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET**

UNIVERSITY OF TORONTO LIBRARY
